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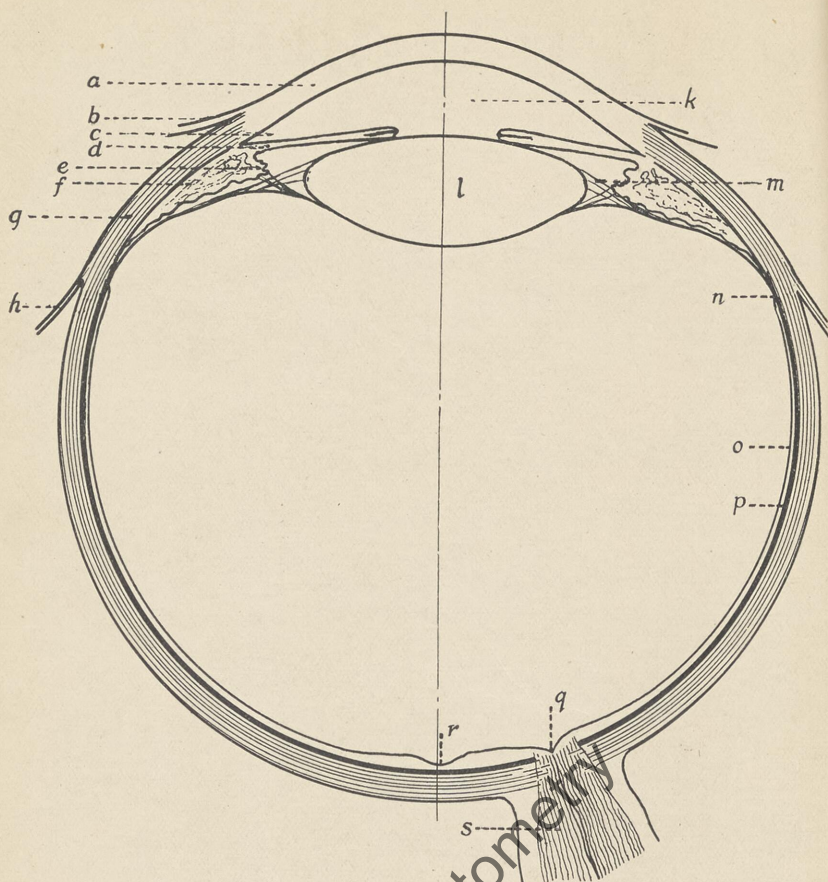
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Horizontal section of left eyeball, viewed from above (semi-diagrammatic).  
 (a) Cornea; (b) conjunctiva; (c) angle of anterior chamber; (d) iris;  
 (e) ciliary process; (f) ciliary body; (g) sclerotic; (h) rectus tendon;  
 (k) anterior chamber; (l) lens; (m) suspensory ligament of lens (zonule of Zinn);  
 (n) ora serrata; (o) retina; (p) choroid; (q) physiological cup in optic disc;  
 (r) fovea centralis retinae; (s) optic nerve.

*Frontispiece.*



# A HANDBOOK OF OPHTHALMOLOGY

BY

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With 12 Plates, containing 41 Coloured Illustrations  
and 194 Text Figures

NEW YORK

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1927



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## PREFACE

THE authors, in writing these pages, have attempted to keep before their minds the fact that the book was intended for undergraduate students and general practitioners. They have, therefore, omitted all reference to the rarities of ophthalmology, and have confined themselves to brief notes upon the uncommon affections. They have dealt in greatest detail with those diseases of the eye and its surroundings which form the bulk of hospital out-patient practice, and have included brief descriptions of the commoner ocular conditions found among medical in-patients. The technique of the usual methods of examination of the eye has been described at some length, in order especially to help the student who is starting his study of ophthalmology. On the other hand, slight reference has been made to more complicated apparatus, such as the corneal microscope.

No attempt has been made to include a bibliography. For the most part the statements made are in agreement with those of larger works, such as Fuchs' text-book of ophthalmology. Acknowledgments are due to the authors of the following books for some of the newer material included in this volume:

Collins and Mayou: "The Pathology and Bacteriology of the Eye."

Goulden: "The Refraction of the Eye."

Basil Lang: "The Routine Examination of the Eye."

Foster Moore: "Medical Ophthalmology."

Whitnall: "The Anatomy of the Human Orbit."

Especial thanks are due to Professor Meller, of Vienna, whose well-known text-book on ophthalmic surgery (Rebman, Ltd.) is the source of a large proportion of the figures, and of some of the descriptive matter in the chapter dealing with operative surgery.

Every effort has been made to amplify descriptions by the inclusion of numerous figures. The authors are indebted to Professor S. E. Whitnall for permission to reproduce Figs. 54, 55, 56 and 112 from "The Anatomy of the Human Orbit" (Frowde, Hodder and Stoughton) to Mr. Holmes Spicer for Fig. 92 and to Mr. Priestley Smith for Figs. 110 and 111 from the *British*



*Journal of Ophthalmology* (Pulman and Sons), to Mr. Duane for the use of Fig. 29 from Fuchs' "Text-book of Ophthalmology," and to the Pathological Department of Moorfields Eye Hospital for micro-photographs of bacteria—Figs. 75 to 78. To Messrs. Theodore Hamblin, Ltd., especial thanks are due for the invaluable services rendered by their drawing department. This is particularly so with regard to the coloured illustrations, most of which were prepared from patients who attended their department. Several of these drawings have already been published, and it is owing to the courtesy of this company that it is possible to reproduce them in this book. The majority of the half-tone and line figures were prepared in the same department from patients, photographs, and rough drawings supplied by the authors. Most of the instruments figured are from blocks supplied by Messrs. J. Weiss & Son.

The authors express their sincere thanks to Messrs. J. & A. Churchill for much helpful advice and great courtesy received during the preparation of the book, and to Mr. Frederick Ridley for his work in assisting them with the reading and correction of the proofs and the compilation of the index.

In conclusion, they would like to express the deep obligation they owe to their respective teachers, Sir John Herbert Parsons and Mr. Leslie Paton, without whose kindly assistance and advice they would not have felt competent to carry out the writing of this book.

HUMPHREY NEAME.  
F. A. WILLIAMSON-NOBLE.

LONDON.

# TABLE OF CONTENTS

	PAGE
CHAPTER I	
<b>Examination of the Eye and its Surroundings</b>	1
Equipment. External examination. Subjective or functional examination. Visual acuity. Field of vision. Colour sense. Examination in dark room.	
CHAPTER II	
<b>Refraction and Accommodation</b>	35
Lenses. Prisms. Errors of refraction. Accommodation. Retinoscopy. Heterophoria. Ophthalmoscope.	
CHAPTER III	
<b>Eyelids and Lacrymal Apparatus</b>	69
Anatomy. Congenital abnormalities. Injuries. Inflammations. Entropion and ectropion. Lacrymal obstruction. Dacryocystitis. Neoplasms.	
CHAPTER IV	
<b>Injuries of the Eyeball</b>	91
Non-penetrating injuries. Penetrating injuries. Rupture.	
CHAPTER V	
<b>The Conjunctiva</b>	105
Anatomy. Congenital abnormalities. Conjunctivitis, superficial and interstitial. Pinguecula. Pterygium. Neoplasms. Phlyctenular conjunctivitis and keratitis.	
CHAPTER VI	
<b>Cornea and Sclerotic</b>	127
Anatomy. Keratitis with loss of surface. Keratitis without surface loss. Interstitial keratitis. Tuberculous keratitis. Scleritis. Staphyloma.	
CHAPTER VII	
<b>Iris, Ciliary Body and Choroid</b>	148
Anatomy. The pupil. Congenital abnormalities. Iritis. Cyclitis. Irdo-cyclitis. Sympathetic ophthalmitis. Neoplasms.	



	PAGE
CHAPTER VIII	
<b>The Lens</b> . . . . .	170
Anatomy. Congenital cataracts. Cataract resulting from inflammation, etc. Senile cataract.	
CHAPTER IX	
<b>The Vitreous</b> . . . . .	183
Anatomy. Congenital anomalies. Traumatic affections. Inflammatory affections. Degenerative changes.	
CHAPTER X	
<b>The Retina</b> . . . . .	188
Anatomy. Developmental anomalies. Traumatic affections. Detachment of the retina. Retinitis. Vascular conditions. Degenerative changes. Neuroepithelioma.	
CHAPTER XI	
<b>The Optic Nerve</b> . . . . .	199
Anatomy. Traumatic affections. Toxic amblyopia. Papilloedema. Optic neuritis. Retrobulbar neuritis. Optic atrophy. Neoplasms.	
CHAPTER XII	
<b>Glaucoma</b> . . . . .	208
Signs and symptoms. Primary glaucoma, congestive and non-congestive. Buphthalmos. Secondary glaucoma.	
CHAPTER XIII	
<b>Extrinsic Muscles</b> . . . . .	218
Paralysis and squint, anatomy and actions of muscles. Paralysis, signs, symptoms and ætiology. Non-paralytic or concomitant squint, ætiology, diagnosis and treatment.	
CHAPTER XIV	
<b>Orbit</b> . . . . .	235
Congenital abnormalities of the eyeball. Injuries. Orbital periostitis. Cellulitis. Cavernous sinus thrombosis. Tenonitis. Neoplasms.	
CHAPTER XV	
<b>Operations</b> . . . . .	242
General considerations. Lacrymal passages. Lids. Squint. Enucleation and its modifications. Cataract. Iridectomy. Trephining. Paracentesis. Tattooing. Conical cornea. Cautery puncture. Use of magnet. Pterygium.	

# TABLE OF CONTENTS

ix

PAGE

## CHAPTER XVI

Ophthalmological Signs and Symptoms in General Medicine . . .	279
Nystagmus. Visual field changes.	

## CHAPTER XVII

Therapeutics . . . . .	290
Systemic treatment. Local treatment: lotions, drops, ointments, lamels.	

Appendix, Services . . . . .	301
------------------------------	-----

Glossary . . . . .	303
--------------------	-----

Index . . . . .	307
-----------------	-----



# LIST OF COLOURED PLATES

		FACING PAGE
PLATE I.	Fig. 34. Fundus in moderate myopia . . . . .	50
	Fig. 36. Fundus in high myopia . . . . .	50
	Fig. 126. Opaque nerve fibres . . . . .	50
PLATE II.	Fig. 58. Blepharitis . . . . .	76
	Fig. 59. Hordeolum (stye) . . . . .	76
	Fig. 60. Chalazion . . . . .	76
PLATE III.	Fig. 63. Lacrymal abscess . . . . .	108
	Fig. 73. Catarrhal conjunctivitis . . . . .	108
	Fig. 74. Angular conjunctivitis . . . . .	108
PLATE IV.	Fig. 80. Conjunctival hæmorrhage . . . . .	116
	Fig. 81. Follicular conjunctivitis . . . . .	116
	Fig. 82. Trachoma (from Lond. Sch. of Hygiene and Trop. Med.) . . . . .	116
PLATE V.	Fig. 83. Phlyctenular conjunctivitis and keratitis . . . . .	121
	Fig. 86. Pinguecula . . . . .	121
	Fig. 87. Pterygium . . . . .	121
PLATE VI.	Fig. 95. Hypopyon ulcer of cornea . . . . .	140
	Fig. 101. Disciform keratitis . . . . .	140
	Fig. 102. Trachomatous pannus . . . . .	140
	Fig. 103. Interstitial keratitis (recovering) . . . . .	140
	Fig. 104. "K.P." (keratic precipitates) . . . . .	140
PLATE VII.	Fig. 114. Iris albino: (1) focal illumination, (2) oph- thalmoscopic . . . . .	155
	Fig. 116. Iritis (pupil partly dilated by atropine, showing irregularity from posterior synechiæ below) . . . . .	155
	Fig. 119. Disseminated choroïdo-retinitis . . . . .	155
PLATE VIII.	Fig. 121B. Lamellar cataract: (1) focal illumination, (2) ophthalmoscopic . . . . .	176
	Fig. 122A. Senile cataract: (1) focal illumination, (2) ophthalmoscopic . . . . .	176
	Fig. 139. Glaucomatous optic disc . . . . .	176
PLATE IX.	Fig. 123. Normal fundus . . . . .	188
	Fig. 124. Albinotic fundus . . . . .	188
	Fig. 125. Tigroid fundus . . . . .	188

		FACING	PAGE
PLATE X.	Fig. 127. Renal retinitis . . . . .		193
	Fig. 128. Diabetic retinitis . . . . .		193
	Fig. 129. Arterio-sclerotic retinitis . . . . .		193
PLATE XI.	Fig. 130. Embolism of central artery of retina . . . . .		195
	Fig. 131. Thrombosis of central vein . . . . .		195
	Fig. 132. Pigmentary degeneration of the retina (retinitis pigmentosa) . . . . .		195
PLATE XII.	Fig. 134. Papillœdema (early stage) . . . . .		203
	Fig. 135. Papillœdema (advanced stage) . . . . .		203
	Fig. 136. Optic atrophy (consecutive type) . . . . .		203



# OPHTHALMOLOGY

## CHAPTER I

### EXAMINATION OF THE EYE AND ITS SURROUNDINGS

#### EQUIPMENT

THE following equipment is required for the ordinary examination of the eye :—

(i.) Snellen's distance test type (Fig. 1); Jaeger's near, or reading, test type (Fig. 2).

(ii.) Ophthalmoscopes. (a) Morton's ophthalmoscope with lenses up to + and - 20 dioptres (Fig. 3); or (b) an electric ophthalmoscope (Fig. 4), such as Marple's, which requires renewal of its small battery at least once a month when in regular use. It will generally be found advisable to arrange for a fresh battery every fortnight if the instrument is used with any regularity. As the ophthalmoscope uses a small standard battery, this is not an expensive method.

(iii.) A condensing lens of about 13 dioptres (focal length of about 3 inches) (Fig. 5). This is usually included in the same case with Morton's ophthalmoscope. It is an advantage that the lens should have a small handle.

(iv.) A plane and a concave mirror (as Priestley Smith's model) (Fig. 6) are requisite if an electric ophthalmoscope is used. The plane mirror is for retinoscopy, the concave for indirect ophthalmoscopy. In Morton's ophthalmoscope large plane and concave mirrors are provided.



FIG. 1.—Snellen distant test type.

(v.) Corneal magnifying lens of  $\times 8$  diameters magnification (Zeiss or Leitz) (Fig. 7).

**TEST-TYPES**

Royal South London Ophthalmic Hospital.  
Corresponding to the "Schmidt-Schaller" of Prof. Edin. Jaeger, Vienna.

(Reprinted from No. 1, 1904, of the Magazine Ophthalmic Specialist)

**Pl. 1.—Landscape.**

For the making of which we had seen  
+ ordered the maps for the expedition.  
These landscapes might last several years  
+ of being good company. For when one  
paysed the other would not have much  
to say. Indeed, I thought of a last  
Glasgow, or the Quality of British  
Kites. The night was beautiful in the  
morning we began the morning are

**Pl. 2.—The Sea.**

For the making of which we had seen  
+ ordered the maps for the expedition.  
These landscapes might last several years  
+ of being good company. For when one  
paysed the other would not have much  
to say. Indeed, I thought of a last  
Glasgow, or the Quality of British  
Kites. The night was beautiful in the  
morning we began the morning are

all their former finery; they  
still loved laces, ribands, bugles,  
and catgut; my wife herself

retained a passion  
for her paduasoy,  
because I formerly

happened to say  
it became her:

**the first  
sunday**

FIG. 2.—Jaeger near reading type.

(vi.) Electric lamp, preferably on a movable arm, so that it is capable of elevation and depression and lateral movement (Fig. 8).



FIG. 3.—Morton ophthalmoscope.

FIG. 4.—Student's electric ophthalmoscope.

(vii.) Drugs: 2 per cent. fluorescein in short lengths of sealed capillary tube or as lamels (Savory and Moore); 2 per cent. cocaine or  $\frac{1}{50}$  and  $\frac{1}{25}$ -grain lamels; 2 per cent. homatropine and



cocaine, or as lamels. (Fluorescein can be prepared in short capillary tubes in sterile solution.)

If it is not desired to carry out retinoscopy for examination of



FIG. 5.—Condensing lens (objective lens).



FIG. 7.—Corneal magnifying lens (loupe).



FIG. 6.—Priestley Smith double mirror for retinoscopy and indirect ophthalmoscopy.

the refraction of the eye, No. (vi.) can be replaced by an electric pendant or an oil lamp.

EXAMINATION.—In the examination of a patient who complains of some ocular disability or discomfort, it is important to bear in mind that the eye is only a part of the organism.

The whole of the picture may be visible only when other parts of the body also are examined. For the eyeball and its surroundings systematic investigation is essential, especially for the student, since it is only by repeated examination of the normal that he can learn to identify the abnormal. It is well that a student should carry in his mind a certain routine method, in order that important signs may not be missed, a recognition of which may completely alter the diagnosis. In

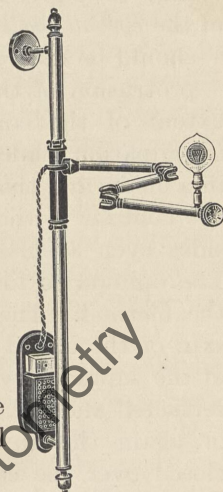


FIG. 8.—Electric lamp on movable arm.



this chapter, the headings under which the method of examination is arranged are printed in italics. These are divided into three portions: I. **External examination**; II. **Subjective or functional examination**; III. **Examination in the dark room**. The *history* of the condition is often of importance, and should always be taken, but it should not lead the student to neglect any part of the systematic examination, by which alone, as already stated, a knowledge of the normal is obtained.

### I. EXTERNAL EXAMINATION

This is carried out by means of a combination of *inspection* and *palpation*. Of the two, the former is far the more important.

The *patient's* general appearance, the colour and expression of the face, and in some cases the condition of the teeth, gums or tonsils, may give important information. The position and form of the *eyeballs and their surroundings*—the forehead and eyebrows—should be noticed. If there is an appearance of exophthalmos—protrusion of the eyeball—or its converse, enophthalmos, the extent of the condition may be measured approximately by examination made in a particular manner. The patient is seated in a chair, and the examiner stands behind her back and inspects the contour of the face from above. By comparison of the two sides even a small amount of exophthalmos may be detected. The opinion so formed can be strengthened by modifications of the method. The patient's head is tilted backwards until the skin of the closed eyelid comes into view below the prominence of the supraciliary ridge and eyebrow; or the upper lid may be retracted and the relative protrusion of the corneæ be observed; or, again, the tip of an index finger may be rested on the eyelid closed over the cornea on each side and the projection of the dorsum of the finger on the two sides compared. Real exophthalmos, such as that due to a neoplasm situated behind the eyeball or to orbital cellulitis, should not be confused with apparent exophthalmos due to enlargement of the eyeball, e.g., in myopia or buphthalmos.

The *movements of the eyeball* are investigated by observation of the eyes while the patient watches the observer's finger moved in all directions. The patient's head should meanwhile be kept stationary. A very careful comparison of the two eyes is necessary for the detection of slight degrees of paresis of an extrinsic muscle of the eyeball, or slight degrees of limitation of movement from other cause, such as conjunctival scarring from injury. The



margins of the *orbit* and their regularity and symmetry should be noted, and any abnormal content which may be felt by the finger to protrude between the eyeball and the orbital margin; the size of the palpebral fissure, whether increased or diminished, and the action of the orbicularis palpebrarum muscle should be examined.

The condition of the *eyelids* should be observed, whether there be retraction or ptosis (drooping) or any swelling; the lashes, as to their position and abundance; the lid margins, as to whether they are red, scaly or encrusted. The Meibomian glands can usually be seen as parallel yellowish lines arranged at right angles to the lid margin, on the conjunctival surface. In order to see them, as also to examine the palpebral conjunctiva, eversion of the lids is necessary.

Eversion of the lower lid is performed by placing the palmar aspect of the index finger upon the lid—left finger on right lid and *vice versa*—so that the ulnar side of the finger is close up to the lid margin. The patient is instructed to look upwards. Gentle traction is applied by the finger to the lid so as to start its eversion. Then slight rotation of the finger in the direction of supination, accompanied by traction, carries this further, so that the inner or conjunctival surface is visible. In cases where there is general swelling of the conjunctiva, as in acute conjunctivitis, or local swelling, as of a chalazion (see Meibomian Gland), backwards and upwards pressure with the tip of the finger will complete the eversion.

Eversion of the upper lid (Fig. 9). (1) By the two-handed method. The patient is instructed to look downwards. The surgeon must see that this is done. To evert the left upper lid a thin rod, held in the surgeon's right hand between forefinger and thumb, is placed with its terminal portion laid in the fold or sulcus above the upper lid. The forefinger and thumb of the left hand take hold of the lashes of the upper lid, somewhat to the outer part of the lid. They stretch the lid gently forwards and towards the temporal side. This lifts the tarsal plate of the lid away from the eyeball. While gentle backward and downward pressure is applied by the glass rod to the upper part of the lid and its tarsal plate, the left hand, maintaining its forward and outward traction, lifts up the lashes, and with them the free border of the lid. As the eversion is completed the left thumb is easily slipped downwards on to the conjunctival surface of the lid to keep it everted, while the right hand places the glass rod



aside. The right thumb then maintains the eversion by gentle pressure against the lash-bearing margin of the lid. *It is essential that the patient's gaze should be directed downwards throughout the performance of the process.* In order to expose the upper fornix the right hand is steadied upon the forehead and vertex with the fingers extended, and the thumb—already in position—applies upward traction upon the lid margin and lashes, while one or two fingers of the left hand apply moderate pressure upon the eyeball through the lower lid. The resulting displacement of the eyeball backwards and upwards pushes orbital fat against the

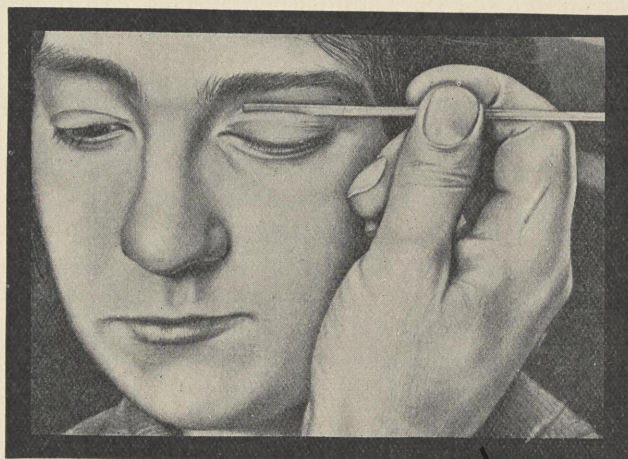


FIG. 9.—Eversion of upper lid. Pine rod in position for two-handed method.

fornix conjunctivæ from behind and exposes it below the everted upper lid.

With the help of a rod the above is, in most cases, the simplest method of performing eversion of the upper lid. In cases, however, where the eyelashes are very short or deficient, considerable difficulty may be experienced. In such cases the one-handed method must be adopted.

(2) One-handed method of eversion (Fig. 10). The patient must look downwards. The right forefinger is placed with its palmar aspect *flat* against the skin of the left upper lid, and starts the eversion by pushing the skin upwards. The forefinger should lie *along* the lid, almost parallel with its margin. The thumb of the same hand then coaxes the lower lid beneath, or posterior to the partly everted upper lid. This increases the eversion. By a some-



what rapid movement of the thumb upwards against the upper lid margin, and of the index finger with a simultaneous supination of the hand, the eversion is completed. The peculiar movement of forefinger and thumb is comparable with that of cigarette rolling. The eversion may be maintained by the tip of the index finger. From this position—with the palmar aspect of the right index finger flat upon the tarsal conjunctival surface—double eversion and exposure of the upper fornix may be performed in a manner similar to the process already described. Except, however, in very lax eyelids, it is usually necessary to help the

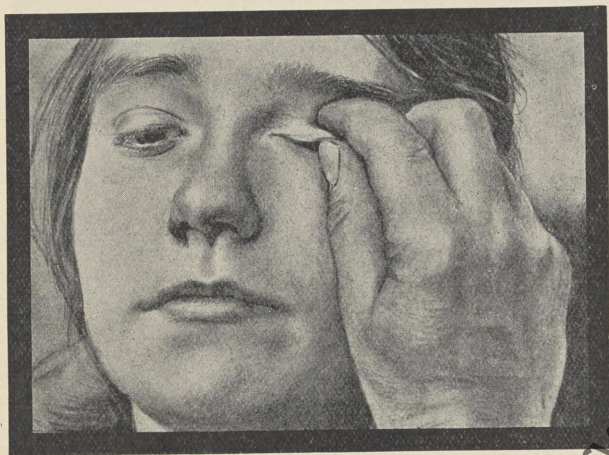


FIG. 10.—Eversion of upper lid. One-handed method. Lower lid beneath upper. Patient looking down. [Drawing by Hamblin.]

eversion with the index finger of the other hand. The right forefinger and thumb evert the outer (temporal) half, while the left index helps to expose the inner or nasal half of the fornix, and *vice versa*.

In addition to the palpebral *conjunctiva*, which is exposed in eversion of the lids, the caruncle, the semilunar fold (*plica semilunaris*, third eyelid in animals), and the ocular *conjunctiva* require notice. The ocular *conjunctiva* is exposed to view by movement of the eye to right and left, up and down, while the lids are retracted.

Of the *lacrymal apparatus*, growth or inflammation of the lacrymal gland may be detected by inspection and palpation of the upper and temporal part of the upper lid. The position of the lacrymal papilla with its lacrymal punctum at the inner end



of the eyelids should be noted, to ensure that it is in normal contact with the eyeball. The presence of retained mucus or pus in the lacrymal sac is detected by pressure with the tip of the forefinger immediately below the nasal end of the lower lid while this is held in a position of eversion by the forefinger of the other hand (Fig. 11). By this means the punctum is actually under observation while the pressure is applied, so that the smallest particle of regurgitating fluid is observed. The method of dilating and syringing the passages will be described later.

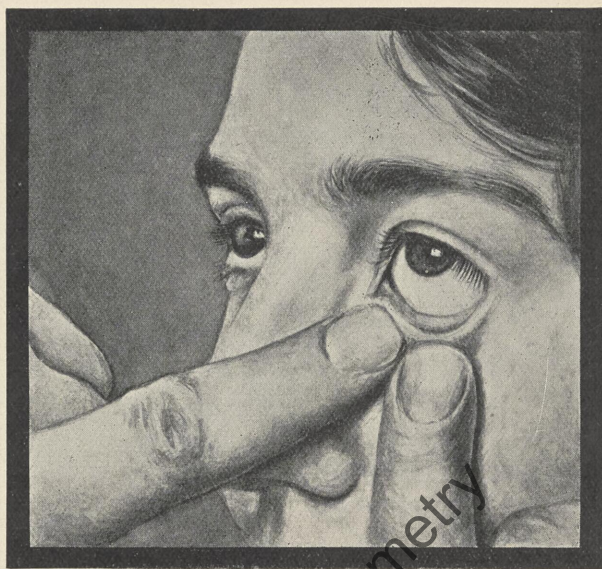


FIG. 11.—Expression of mucocele or testing for regurgitation from lacrymal sac.

Inspection of the *sclerotic* is made for abnormalities of colour or of general shape, the presence of localised swelling or of circumcorneal or ciliary injection.

Examination of the *cornea* is facilitated if the light, whether daylight or lamplight, be focussed upon it by means of a condensing lens as described in detail on p. 20. This is especially true in the inspection of delicate corneal opacities. The surface regularity or "polish" of the whole cornea should be carefully examined. For this purpose, whether a condensing lens be used or not, the patient is directed to follow the movements of a finger in every direction. If there is even a minute loss of surface epithelium from ulceration or abrasion, or the presence of a very



small foreign body on the surface, this is made evident by an interruption or irregularity in the reflexion of the light source. If a well-lighted window be the light source, the reflexion of the window seen in the cornea will be distorted or broken at the site of any corneal abrasion or ulceration. When there is uncertainty as to the presence of such surface damage, a droplet of 2 per cent. fluorescein applied to the white of the eye above the cornea will disclose the lesion by giving it a bright green colour. (Note capillary tube or lamels in list of drugs.) Ulceration of the conjunctiva, on the other hand, is stained a bright orange-yellow colour by this solution. The transparency of the cornea or the presence of general or localised opacity are noted. For convenience of description, the intensity of opacification is referred to as a *nebula* if of slight degree, a *macula* if of moderate, and a *leucoma* if of extreme, density. Vascularisation of the cornea takes place in various conditions. Superficial vessels are bright red in colour, and are in continuity with conjunctival vessels. Deep vessels are dull red in colour and make their appearance at the limbus. The sensitivity of the cornea, often impaired in glaucoma, is tested by comparison with the opposite eye. A wisp of moistened cotton wool is drawn out and applied to the centre of the cornea while the eyelids are held apart. If the sensitivity is normal, an attempt is made by the patient to close the eyelids, or the eye is turned upwards.

*Examination of the Cornea of an Infant* (see Fig. 12).—In babies in whom the conjunctiva is acutely inflamed, retraction of the eyelids with the fingers is difficult to accomplish without causing complete eversion of the eyelids, owing to the vigorous action of the orbicularis muscle in crying. It is necessary, therefore, in many cases to use a retractor, at least for the upper lid. With the help of a long towel or a blanket, it is possible for two to carry out this examination. The surgeon and the nurse are seated facing one another. The child, with its arms confined within the blanket in which it is rolled, is laid with its head towards the surgeon. The head is supported and somewhat gripped by his knees. The nurse supports and controls the child's body, and has one hand free with which to hold, if necessary, a retractor for the lower lid. By this means the surgeon has his hands free, so that one can hold a retractor for the upper lid and the other can instil drops or apply direct treatment to the cornea. Great gentleness in retraction of the eyelid with a finger is necessary in order to avoid damage to the corneal surface. The



surgeon should beware of pent-up secretion, which may be ejected forcibly into his own eye when he separates the child's eyelids. In order to protect his eyes and hands from infection in doubtful cases he may wear goggles and rubber gloves.

*The depth of the anterior chamber* is examined while the eye is made to look from side to side. Its depth becomes apparent partly by means of the observer's stereoscopic vision, partly by the plane in which the iris is seen to lie on each side of the pupil,

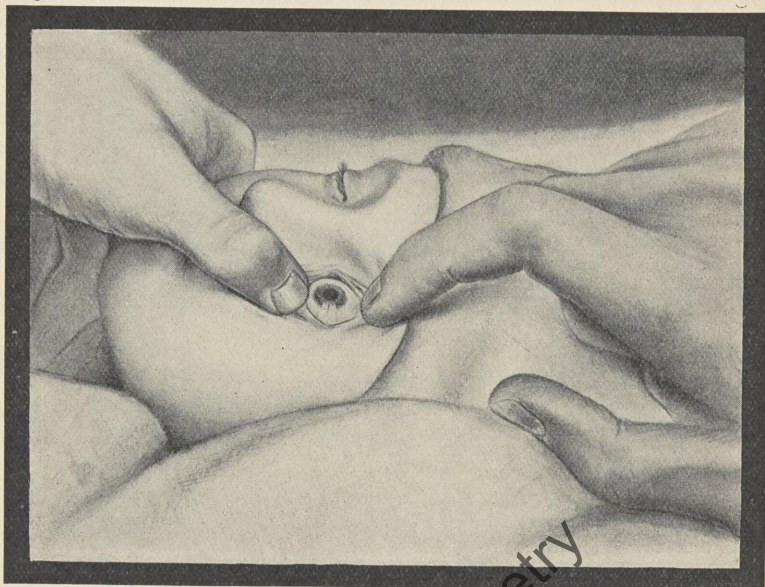


FIG. 12.—Examination of a child's eye. This may require a considerable amount of pressure with the fingers upon the lids. In the first examination of any case in which such pressure seems necessary, an eyelid retractor should be used in order to avoid possible perforation of a corneal ulcer. The finger nails must not be long. [Drawing by Hamblin.]

and partly by the presence of light or shade on the iris. (It is shallow in glaucoma, and deep in dislocation of the lens or after cataract extraction.) The anterior chamber may contain clear aqueous humour, a collection of blood—hyphæma (see p. 93)—from trauma or severe inflammation, or a collection of pus—hypopyon—in certain ulcerated conditions of the cornea. There may be small grey-white spots or minute dots composed of chronic inflammatory cells deposited from the aqueous on to the deep surface of the cornea. These deposits are most obvious in the front of the lower part of the anterior chamber. They



are known as "K.P.," or *keratic precipitates*, and are a sign of inflammation of the ciliary body—cyclitis—from which structure the cells are extruded. In some cases a cellular exudate accumulates in the lower part of the anterior chamber, and later becomes organised into a white membrane of fibrous tissue adherent to the deep surface of the cornea (especially in tuberculous iridocyclitis and severe interstitial keratitis of syphilis). The presence of tremulous *iris* or iridodonesis is observed in cases of absence or dislocation of the lens, owing to the lack of the normal support given to the iris by the lens. In the examination of the iris attention should be paid to its colour ("muddy" or discoloured in iritis), its pattern (obscured in iritis), and its plane (the pupil margin displaced forwards in primary glaucoma, backwards in dislocation of the lens, etc.). The presence of posterior synechiæ—adhesions of the pupil margin to the anterior lens surface—in active or old iritis, is best seen after a mydriatic has been used. The *pupil* varies in its size, shape and position. The *pupil reactions* which result from exposure to light and from accommodation-convergence are conveniently examined as follows: The patient is directed to look towards a lamp or window. Each eye is shaded with the hand, but the right in such a way that its pupil is visible to the surgeon. The right eye is then uncovered and the speed and range of contraction of its pupil are noted (direct reaction). The extent to which the pupil dilates again during the next few seconds is of significance. The left eye is then uncovered, and the further contraction of the right pupil is observed (consensual reaction). The process is repeated for the left eye. The patient is then instructed to look fixedly at a pencil held about a metre in front of his eyes. The pupils are watched and the extent of their contraction noted during the rapid approach of the pencil to within a few inches of the root of the nose (reaction in accommodation-convergence). Sluggish reactions may indicate early iritis. Failure to maintain the contraction often occurs in early glaucoma, retrobulbar neuritis, or disseminated sclerosis. Contraction with accommodation-convergence, but absence of contraction on exposure to light, may be the first sign of tabes dorsalis, and is known as the "Argyll-Robertson pupil."

The *lens* is only satisfactorily examined after dilatation of the pupil has been effected by a mydriatic. A suspicion of the presence of an early cataract may be entertained on examination through the undilated pupil, but thorough investigation necessitates dilatation. Rarely, a white inflammatory mass in the



*vitreous*, or an intraocular neoplasm may be visible through the pupil in external examination.

Inflammation of the *ciliary body* is sometimes associated with severe tenderness on palpation over the ciliary region.

The *tension* of the eyeball should be tested in every case. To carry this out the patient is instructed to look down, and the index fingers are rested lightly side by side on the eyeball, well posterior to the corneo-scleral junction, while the hands are steadied by resting the little finger on the temple or forehead. One finger remains passively supporting the eyeball, while the other presses very lightly so as to try and indent the surface. The ease or difficulty of indenting the eyeball, and also the sensation of fluctuation imparted to the resting or passive finger, indicate the tension. The tension is indicated by the sign + or —, according as it is above or below that of the normal eye. If the eye is of stony hardness, it is denoted as  $T + 3$ ; if it is of such tension that a moderate amount of pressure is required to indent it, the tension is referred to as  $T + 2$ ; if only a slight increase of pressure above the normal is necessary it is  $T + 1$ . In a similar manner, reduction of tension is denoted as  $T - 1$ ,  $T - 2$ ,  $T - 3$ . In the last the tension is so reduced that the eyeball is almost like a flaccid thin-walled bag, merely containing fluid. Measurements can be made with a fair degree of accuracy by means of an instrument known as a tonometer.

## II. SUBJECTIVE OR FUNCTIONAL EXAMINATION

This is divided into :—

- (a) Vision, *visual acuity* or form sense
- (b) *Field of vision*, and testing for (i.) scotomata, (ii.) peripheral field limitation.
- (c) *Colour sense*, and testing for (i.) congenital defects; (ii.) acquired defects (retrobulbar neuritis, optic atrophy, toxic amblyopia).

(a) The **visual acuity** is tested by means of "Test Type." Snellen's test type is such that, at the "normal" distance, the angle subtended at the eye by the height or breadth of each letter is 5 minutes. The thickness of the stroke or line forming the letter is one-fifth of this, *i.e.*, it subtends an angle of 1 minute. The type for testing at a distance is composed of capitals, and for near vision ordinary small type (see Figs. 1 and 2). The visual acuity for distance is represented by a vulgar fraction. The numerator



denotes the distance in metres at which the patient is placed from the test type. The denominator is the distance in metres at which a normal person with normal vision should be able to read that particular type. For example, the largest letter of the test type should be distinguishable at 60 metres; at this distance it subtends an angle of 5 minutes. If a patient tested at 6 metres is able to read this letter, and none smaller, his vision is referred to as V.R. or V.L. = 6/60 (R. = right, L. = left). The letters of successive rows of the test type are of such size that the "normal" distances are 60, 36, 24, 18, 12, 9, 6, 5, 4 metres respectively. A person with normal vision should be able to read any of these lines at their correct distances. In ordinary circumstances a patient is placed 6 metres from the test type, which is well illuminated, preferably by electric light of constant brilliancy. In these circumstances the numerator of the fraction which represents the visual acuity will always be 6. If in a particular patient no more than the third line is read, the vision is said to be 6/24, or if the sixth line, 6/9. If the vision is so defective that even the largest letter is not distinguished, the following further tests are applied in order:—

"Finger-counting at 1 metre," which equals approximately 1/60, for the thickness of the strokes of the largest letter of the test type is approximately equal to the average thickness of the adult index finger.

"Hand movements at 1 metre."

"Perception of shadows," in which the shadow of the hand as cast by an ordinary lamp of 30 or 40 candle-power is allowed to fall upon the face of the patient.

"Perception of light" (P.L.), in which bright light concentrated upon the pupil by means of a convex lens or a concave mirror is alternated with darkness.

The distant vision of illiterates can be tested with a chart on which the letter E, of size corresponding with that of the capitals on the ordinary Snellen test type, is arranged in different positions, thus, E E E.

Near vision is tested for the purpose of proving that the accommodation or focussing power of the eyes is present, and in the provision of reading glasses. Since the visual acuity, or form sense, is examined carefully at a distance of 6 metres, as above described, there is no necessity in the testing of near vision to have extremely small print.

The accurate testing of *light sense* is fraught with such difficulties



that at the present time it is limited almost entirely to research work. The light sense is investigated by estimating the lowest intensity of light that is appreciated in certain constant circumstances, and also by noting the smallest change of intensity of light which is realised. The former is referred to as the "minimal value," the latter as the "light difference."

(b) **The field of vision** is examined mainly for (i.) blind areas at or near the centre of the field; (ii.) limitation of the peripheral field. For practical purposes, the central portion of the field is usually examined with a small red object, such as a 1 cm. square of red or blue card. This will be referred to in the next section, on "colour sense." The limits of the peripheral field can be examined in many different ways. Three main methods will be described. (1) As a preliminary test, to exclude gross loss of field, the patient is examined in daylight. He is placed facing the surgeon and looking directly at him, eye to eye. His field of vision is compared with that of the surgeon. If the field of the patient's left eye is to be examined, his right eye and the left eye of the surgeon are obscured. The surgeon uses his fingers, or a white visiting card held on a long pin or between the points of a pen. The object is moved from the periphery in a vertical plane midway between the patient and the surgeon. In the temporal direction the object should be visible however far away it is placed, for the normal field in this direction extends laterally for more than 90 degrees when the gaze is directed forwards. In an upward direction, and on the nasal side, the field of vision extends approximately for 60 degrees from the visual axis and below for 70 degrees. By moving the object midway in the plane between himself and the patient, the surgeon can compare the visual field with his own. By this means an extensive loss of the peripheral field, such as occurs in most cases of detachment of the retina, can readily be detected. (2) In the case of a patient whose vision is very defective, as with advanced cataract, movements of the fingers or of a white card will not be detected. In such a case the field must be examined in the dark room, with light reflected from a mirror as the moving object. The patient, with one eye covered, is instructed to look directly forwards, and his eye is watched by the surgeon to see that the instruction is obeyed. Light from a lamp above and behind the patient's head is reflected on to the eye under examination from various directions, by means of a large ophthalmoscope mirror. The patient is instructed to point with his finger in the direction from



which the light appears to come. In the case of serious loss of peripheral field in any one direction, the patient may be conscious of the light, but be unable to point accurately in the direction from which it is projected. The patient's "light projection," or "projection of light," is then said to be defective in the direction concerned, nasal, temporal, or otherwise. (3) The third method of examining the field of vision is by means of a perimeter. A

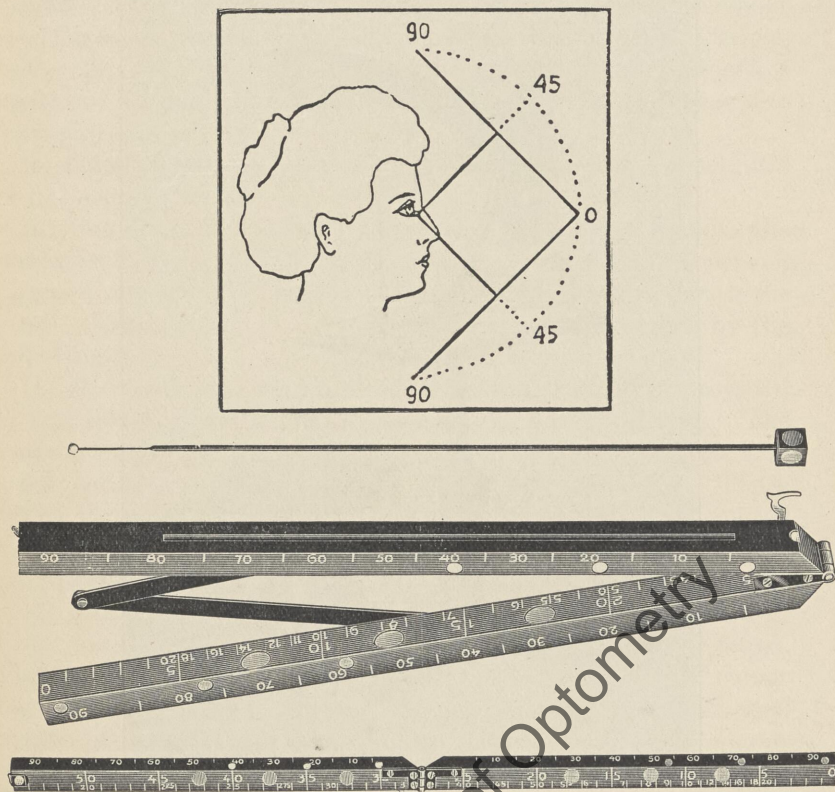


FIG. 13.—Hand perimeter (Holth).

small hand-perimeter, such as that designed by Holth (see Fig. 13), which is in the form of a folding ruler, is capable of giving more accurate results than the method already described. The graduated folding ruler is maintained at a fixed distance from the patient's face, and a small white object carried on a thin black rod is moved along the arm of the instrument, which is held in various positions. For the student or general practitioner this method will be found to be simple and reasonably accurate.



For especially careful investigation of the fields, and particularly for the observation of changes in the size of the peripheral field, a larger and more accurate machine is required. Furthermore, constancy of illumination is of considerable importance. The size of the field as taken in dull daylight in a poorly-lighted room

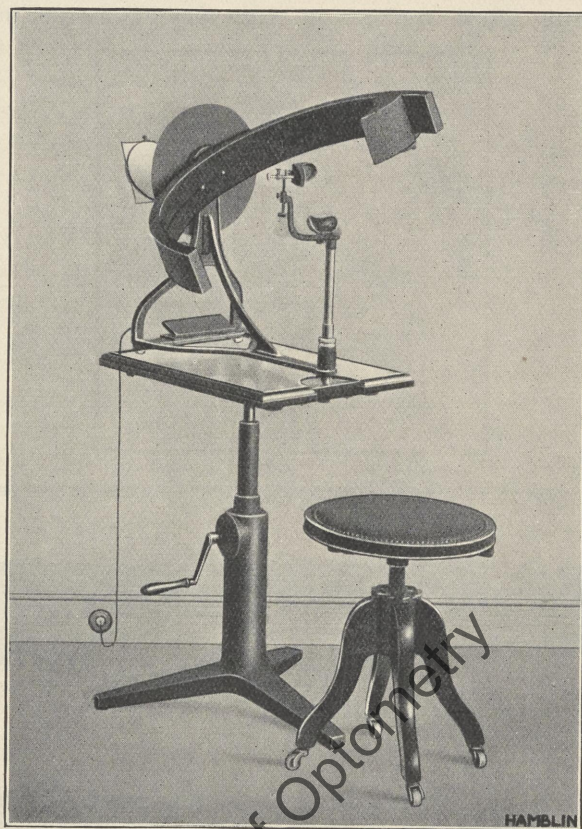


FIG. 14.—Lister perimeter and scotometer.

will be found to be very much smaller than when taken in bright daylight in a well-lighted room. For this reason the Lister perimeter (see Fig. 14) is one of the most satisfactory of the self-recording instruments, in that it has its own electric light on the moving arm. Furthermore, it has an arrangement whereby accurate measurements of the blind spot and of scotomata in the neighbourhood of the centre of the field can be taken. Contrac-



tion of the field of vision takes various forms. Concentric contraction of the field takes place frequently in optic atrophy ; a sector-shaped contraction or field loss, in glaucoma, particularly on the nasal side ; homonymous hemianopsia, or loss of half the field, either nasal or temporal in each eye, in certain lesions causing pressure on the optic tract ; bi-temporal hemianopsia, or loss of temporal field of each eye, occurs in cases of pressure in the neighbourhood of the optic chiasma. Loss of field for colour sometimes precedes loss of field for a white object ; for example, there may be a bi-temporal hemianopsia when a red object is used, but no hemianopsia when a white object of the same size is employed.

(c) **Colour Sense.**—Defect of colour sense may be (i.) congenital or (ii.) acquired.

(i.) **CONGENITAL COLOUR BLINDNESS** (Daltonism) prevents the victim from seeing colours in the same way as the normal person, e.g., in a marked case, reds and greens are confused one with the other. The presence of colour-blindness may be detected by the following tests :—

(1) *Holmgren's Skeins of Wool.*—The skeins of wool provided in this test are of different colours and of various shades. The surgeon picks out, one at a time, a number of skeins of red, and a number of green hue, and asks the name of the colour. Those which are called red should be put in one group, and those called green in another, out of sight of the patient. Marked cases of colour-blindness can be detected by this means.

(2) *Stilling's pseudo-isochromatic* coloured plates, published in book form (similar to Edridge-Green's and Ishihara's tests). Plates are printed with round or irregularly shaped spots of colour on a white ground. Two main colours of varying shades are used in each plate. The plate is occupied chiefly by spots of one colour, with spots of the other colour arranged in the form of a number. The number on each plate is recognised by a man with good colour vision owing to the difference in colour.

(3) *Edridge-Green's Lantern Test.*—A lantern with an aperture of small but variable size is constructed so that glass of different colour can be placed in front of the light. The patient is placed 20 feet from the lantern in a subdued light. He is asked to name each coloured light as it is shown, and a record is kept of the answers.

For scientific investigation of colour vision a spectroscope is necessary.



(ii.) ACQUIRED DEFECTS OF COLOUR SENSE.—In acquired defects of the colour sense a peripheral portion of the visual field may be insensitive to a particular colour or to any except white ; or, on the other hand, the centre of the field may have defective colour sense. In examination of the field with a coloured object, whether it be by hand or by means of a perimeter, it is important to impress upon the patient that as the object is moved inwards from the periphery, he is to say when he appreciates *colour*, and not merely when he realises that the object is *moving* within his field of vision ; that is to say, if the red object is moved inwards from the periphery, he is to say when he realises that it is a red object, and not when he first sees something moving. In the normal person the field for a blue object is usually the largest, for a red object next, and smallest for a green object. (Refer to pages showing figures of different field contractions.) The loss or impairment of the central part of the field, that which includes what is called the “fixation point,” is referred to as a “*central scotoma*.” A similar defect in the immediate neighbourhood of the fixation point is referred to as a “*paracentral scotoma*.” An insular defect in the peripheral field is known as a “*peripheral scotoma*” and occurs in conditions of destruction of the retina or choroid, as in choroiditis. If a patient is conscious of the presence of a blind area in his field he is said to have a *positive scotoma*. In most cases the patient is unconscious of such an area unless it be particularly large. If he is unconscious of the defect he has a *negative scotoma*. If the defective area is incapable of receiving impressions from a white object, the defect is known as an *absolute scotoma*. If it is insensitive only to coloured objects it is a *relative scotoma*. Every normal individual has a small absolute scotoma centred at 15 degrees to the temporal side of the fixation point. This corresponds with the optic disc. In order to demonstrate the blind spot, one eye should be closed ; the other eye should be made to fix a certain point, preferably a small white spot on a neutral grey background, such as a light black-board or a piece of grey paper. A small white object, such as the white head of a pin, a white bead fixed to the end of a straight wire, or a square of white card held between the points of a pen nib is used as a moving object. This white object is moved slowly from the fixation point, in front of the background, outwards horizontally in the temporal field. At about 15 degrees from the fixation point it will disappear. Enlargement of this scotoma or blind spot is often one of the earliest signs of chronic



glaucoma. Its size can be charted by placing the patient accurately at 1 metre distance from the neutral background, with his eye level with the white spot used as the fixation point. The object used should always be of the same size if a comparison is required to be made on different occasions. The object should be moved from within the blind area outwards in every direction. At the point in each movement at which, according to the patient, it becomes visible, a small mark can be made on the background. It is quite impossible to chart accurately a central scotoma owing to the fact that the eye under examination is unable to fix any point steadily if the scotoma be absolute. A central colour scotoma, or relative scotoma, is an important sign in toxic amblyopia, retrobulbar neuritis, and disseminated sclerosis. These conditions are uncommon. The least uncommon type of toxic amblyopia in this country is tobacco amblyopia, due to poisoning by nicotine. The detection of a central colour scotoma may be made by moving a piece of coloured card, bright red or blue, of from 1 to 5 mm. diameter, held on the point of a long pin or between the points of a pen nib. The patient should be made to fix one eye as far as possible upon the eye of the observer. The small coloured object is then moved from side to side and up and down across the central field of the patient. In some cases, the perception of the colour is completely lost in the centre of the field, but reappears on either side. In others, the brightness only of the colour is reduced in the central area. Holth's hand perimeter, referred to above, has an arrangement of three coloured spots marked on it which make a very simple test for the presence of central colour scotomata. The patient is instructed to fix the central of the three coloured spots with the eye under examination while the other is covered, and to notice whether there is any difference in the brightness of the colours of the three spots. If there is a defect of colour perception in the macular area—a relative central colour scotoma—the central spot appears less bright, or of less saturated colour, than the lateral spots.

### III. EXAMINATION IN THE DARK ROOM

- (i.) Oblique focal illumination.
- (ii.) Direct ophthalmoscopy at a distance.
- (iii.) Indirect ophthalmoscopy.
- (iv.) Direct ophthalmoscopy.
- (v.) Transillumination.



(i.) **Oblique focal illumination** is usually carried out, as a preliminary, in the examination of the patient by the naked eye in daylight. Gross changes of the cornea, the iris and the lens are noted, as described in Section I. (p. 4). In the dark room the examination is assisted by the use of a corneal magnifier (Fig. 7), a pocket lens of  $\times 8$  or  $\times 10$  magnifications. A lens of eight magnifications is the better for ordinary purposes. The method

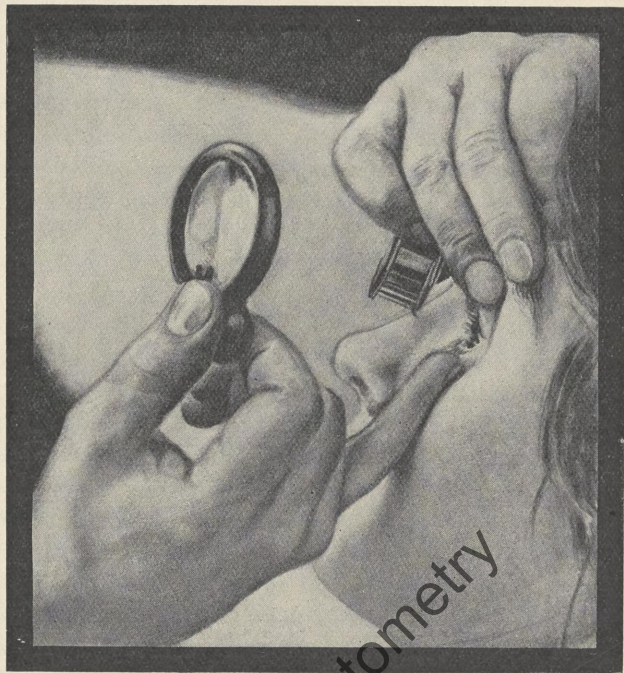


FIG. 15.—Examination with oblique focal illumination. The surgeon stands on the patient's right hand for the examination of each eye. The light is in front and to the left of the patient.

[Drawing by Hamblin.]

advocated here avoids the necessity of moving the lamp from one side of the patient to the other. The source of light should be placed to the right side of the observer's head and preferably slightly behind him. (It is taken for granted in this description that the observer uses his right eye in this examination by oblique or focal illumination. If his left eye is the better, the position will be reversed, and "left" should be read "right," and *vice versa*.) The patient is seated and the observer stands on his right side (Fig. 15). To facilitate the examination the patient's head is tilted



slightly backwards, and, to begin with, his gaze is directed midway between the lamp and the observer's head. A large or condensing lens, preferably fitted with a small handle, is held by the surgeon between his right forefinger and thumb. The little finger, or the ring and little fingers, are placed on the lower lid, either of the right or left eye, whichever is under examination. It is important that the hand should be fully supinated in order to have the condensing lens in a good position for focussing the light. In this way the lens is held between the source of light and the eye, so as to focus the source of light upon the cornea. In the meantime the little finger is able to retract the lower lid, so as to give a more complete view of the eye. The surgeon's left hand holds, between the forefinger and thumb, the opened corneal magnifying glass. The ulnar side, or ulnar part of the palm, of this hand rests on the patient's forehead. The middle finger should then be in a position in which it is capable of elevating the upper lid, whether the right or the left eye be under examination. Lastly, the surgeon places his own right eye close behind the corneal magnifier. The closer it is placed to the magnifier the larger will be the field visible through the lens. When a high magnification, as with a ten-diameter lens, is used, it will be found an advantage to rest the forehead lightly upon the base of the left index finger in order to obtain a more accurate adjustment of the focus. While the eye is under illumination by this means the conjunctiva and the cornea can be examined in detail. In the process of examination the condensing lens held in the right hand is moved from side to side or up and down in order to illuminate the structures with the brightly focussed image of the source of light in all their parts. The patient is, meantime, directed to look upwards or downwards or to the side, in order to expose to better advantage particular parts of the cornea. This movement, both of the patient's eye and of the focussed light, is of the utmost importance; for example, a small collection of "K.P." (keratic precipitates) situated on the posterior surface of the lower part of the cornea may be entirely overlooked unless the patient's eye be directed upwards to the fullest extent. Examination with the corneal magnifier reveals in greater detail features seen by the naked eye, and also exposes to view details that may have been quite invisible by that method. The surface of the cornea, its degree of polish, the presence of local or general roughening, projections or depressions, should be noted. The presence of foreign bodies, of a nebula, a macula, or a leucoma,



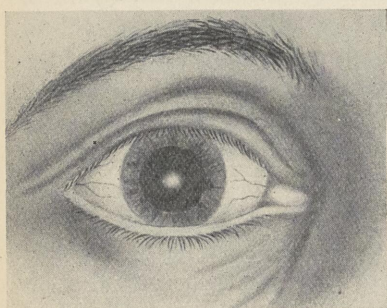
and the exact situation of these, are seen. The position in relation to the thickness of the cornea of a foreign body or an opacity can be determined by means of parallax. Examination for parallax is best carried out with a lens of ten-diameter magnification, but can be made with care with an eight-magnification lens. Let it be assumed that there are two spots, either foreign bodies or opacities, one on the anterior surface of the cornea and one on its posterior surface, one directly anterior to the other in a line at right angles to the surface. If observation be made through the corneal magnifier along this line, only one spot will be seen. If the surgeon's eye, with the lens in front of it, be moved to the right, the anterior spot, that on the anterior surface, will appear to move to the left, and the posterior spot will come into view by appearing to move to the right. If the surgeon's eye be moved in the opposite direction, the opposite will take place. If, now, there be only a spot on the posterior surface, for example, a deposit of "K.P.," in order to determine that this is situated deeply it will be necessary to find something on the anterior surface with which to compare its position by parallax. Such object can generally be found in the presence of a speck of dust or small bubble in the normal layer of moisture from the tears which slowly moves downwards across the cornea. In a similar manner the relative depth of vessels in the cornea can be ascertained. A superficial vessel will appear to move across a deep vessel in a direction opposite to the movement of the surgeon's head. The realisation of parallax with regard to the cornea is not easy of accomplishment. It is considerably easier, however, to ascertain by parallax the difference in depth of an opacity in or on the cornea from that of a collection of exudate in the anterior chamber or on the iris.

After the completion of a careful examination of the cornea and conjunctiva a scrutiny is made of the iris, in order to note the condition of its surface, the pattern, the colour, any irregularities of colour, the presence or absence of exudate or nodules or blood-vessels on the anterior surface, the presence of anterior or posterior synechiæ. The lens is examined for the presence of white or pigmented deposits on its anterior surface, and for the presence of opacities which ordinarily appear white or grey-white by focal illumination (see Fig. 16). Just as the reflexion of the source of light is seen on the anterior surface of the cornea as a brilliant image so the reflexion of the light source is visible on the normal anterior surface of the lens, but very much less brilliantly. This

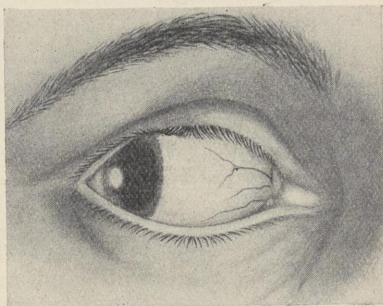


reflexion is best seen when the patient directs his gaze approximately midway between the light source and the surgeon's head. In the absence of the lens, as in dislocation into the vitreous, no such light reflex is obtainable.

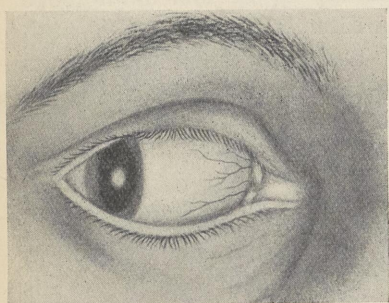
(ii.) **Distant direct ophthalmoscopy** is carried out preferably with the large plane mirror of Morton's ophthalmoscope or with



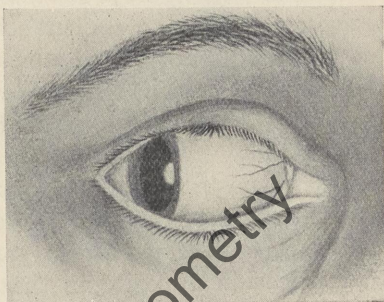
I.



II.



III.



IV.

FIG. 16.—Opacity in cornea and lens.

- I. Shows the appearance of an opacity when the eye is looking directly forwards, whether this opacity be in the centre of the cornea, the front of the lens or the lens substance, or its posterior pole.
- II. Shows an opacity situated in the centre of the cornea, the eye being turned to the right.
- III. Shows an opacity in the centre of the anterior surface of the lens.
- IV. Shows an opacity within the lens substance.

[Drawings by Hamblin.]

the plane mirror of Priestley Smith's (see Fig. 6). Failing a large plane mirror, a concave mirror can be used. In this method of examination, the lamp is placed above and behind the patient's head. The light is reflected by the mirror, held close in front of the surgeon's eye, from 1 to 2 feet away from the patient. The following details are observed: (i.) The red reflex through the



pupil from the fundus of the eye ; (ii.) the bright reflexion in the cornea, the image of the source of light ; (iii.) the presence of any opacities in the media ; (iv.) the patient's light projection or field of vision for bright light (see p. 14). The red reflex is noted while the patient moves his eye in every direction, and any change in the brightness of the red colour is observed. In cases of detachment of the retina there is usually some diminution of the brightness of the colour or change to yellow or greyish-yellow colour in the region affected. The position of the reflexion of the source of light as seen in the cornea indicates the direction of the optic axis of the eye. Normally the bright image of the light is seen slightly to the nasal side of the centre of the cornea. In a case of convergent squint, the bright image is seen towards the temporal side of the cornea in the affected eye. Opacities in the media are observed as dark spots or shadows on the red reflex seen through the pupil. By means of parallax the position of an opacity causing a dark shadow can be ascertained. A central opacity in the cornea will appear in the centre of the red reflex when the patient's eye is looking directly at the ophthalmoscope mirror. When the patient's eye is directed upwards this dark spot will appear to move upwards. A similar central opacity on the front of the lens will appear to remain in the centre of the red reflex, whether the eye be directed forwards or upwards or downwards. An opacity at the centre of the posterior pole of the lens, *e.g.*, posterior polar cataract, will appear to move downwards in relation to the disc of red reflex when the eye is directed upwards. In other words, opacities in front of the pupil appear to move in the direction opposite to that in which the surgeon moves his head, opacities behind the pupil appear to move in the same direction (see Fig. 16). Floating opacities in the vitreous, as from hæmorrhage or exudate resulting from inflammation, are distinct from the former or fixed opacities in that movements of the eye from side to side cause the opacities to appear to float. In order to test for the presence of floating opacities in the vitreous, the patient should be instructed to watch closely the surgeon's finger. A sudden movement of the finger from one side to the other while careful observation is made of the red reflex will impart a swinging or floating movement to the vitreous opacities which is quite distinctive. All the opacities, described as above, if they are of small size, are seen in greater detail and with greater facility by direct ophthalmoscopy (to be described later). Subluxation or partial dislocation of the lens can usually be



detected by distant ophthalmoscopy. If the equator of the lens is displaced to one side, it is clearly visible within the circle of the red reflex, owing to the different refraction of the lens from that of the other media.

(iii.) **Indirect ophthalmoscopy** is carried out by means of a concave mirror and the lens used in focal illumination. The lens is here spoken of as the "objective" lens. The mirror is the large concave mirror of the Morton ophthalmoscope with a circular hole in its centre or a clear circle of transparent glass. As an alternative, the concave mirror of the Priestley Smith ophthalmoscope may be used. By this method, as the name implies, a direct view of the fundus is not obtained. The image

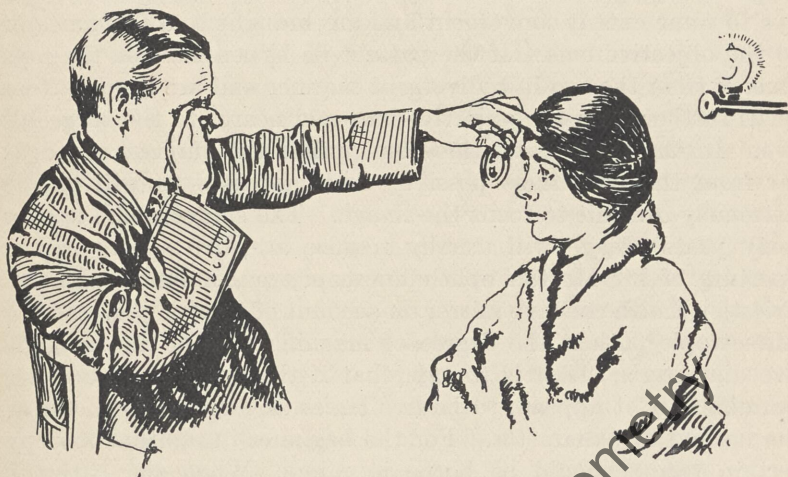


FIG. 17.—Indirect ophthalmoscopy.

seen is inverted, that is to say, the upper part of the fundus appears below, the nasal part appears to the outer or temporal side; in fact, *a real inverted image is produced between the observer's eye and the objective lens*. A lamp is placed above and behind the patient's head. The light is reflected by the ophthalmoscope mirror into the pupil of the patient. The objective lens is held in the line of these rays a short distance in front of the patient's eye. If the surgeon has with his right eye equal or better vision than with the left he will find it more convenient to examine both eyes of the patient with his right. He holds the ophthalmoscope mirror in his right hand with the central aperture in front of his eye, the objective lens in his left hand between the forefinger and thumb, while he rests the little finger of the same



hand upon the patient's forehead or right cheek-bone (see Fig. 17). As the inverted image is situated in the space between the objective lens and the surgeon's eye, it is necessary for the latter to accommodate to some extent in order to focus the image clearly. For the same reason, it is advisable that he should stand at or about arm's length from the patient. If the patient is emmetropic and his accommodation is relaxed completely, or he is under the influence of atropine or homatropine, so that accommodation is abolished, the rays of light emerging from the retina are made parallel by his own lens. These parallel rays then meet the objective lens and are brought to a focus at a distance from it equal to its focal length, and on the same side of it as the surgeon. If the patient be myopic, the rays emerge from the eye to some extent convergent and are brought to a focus nearer to the objective lens. If the patient be hypermetropic the rays emerge from the eye in a divergent manner and are brought to a focus further from the objective lens and nearer to the surgeon's eye. In the latter case, therefore, unless the surgeon stand as far from the patient as possible, in some cases he will find it extremely difficult to focus the image. The surgeon who is over forty years of age will usually require a  $+2.0$  sphere in the aperture of his Morton ophthalmoscope, or combined with his Priestley Smith concave mirror on account of presbyopia. In the emmetropic patient the degree of magnification of the image is five diameters. That is to say, that if the optic disc be under examination, it appears to be five times as large in diameter as the normal disc diameter. For the beginner in ophthalmoscopy certain points should be borne in mind. When the patient's right eye is examined he should be instructed to look slightly to his left, in order that the optic disc may be seen by the surgeon. If the latter hold the ophthalmoscope in his right hand horizontally he should hold his little finger erect and instruct the patient to look at the tip of the little finger (see Fig. 17). In this position, if he look through the ophthalmoscope with his right eye, he should see the image of the patient's optic disc projected in space on the line joining the patient's pupil with his own pupil, provided that the objective lens be centred on this line. In order to examine the left optic disc the surgeon should instruct the patient to direct his gaze to the tip of the surgeon's left ear. If the surgeon use his left eye the directions of gaze should, of course, be reversed. Secondly, the light from the ophthalmoscope mirror must be directed accurately on to the



patient's eye and be focussed there by the objective lens, so that the bright red reflex is seen through the patient's pupil. Thirdly, the surgeon should commence his examination by standing at arm's length from the patient. Fourthly, the objective lens should be held at first close to the patient's eye and gradually withdrawn from it. Fifthly, as it is being withdrawn it should be moved slightly up and down and from side to side. This movement brings a different portion of the fundus into view, so that if the patient's eye is in a line so as not to project the image exactly in the right place, the optic disc may, nevertheless, be brought into view. Sixthly, the brilliant reflexions of the source of light which are produced by the patient's cornea and the objective lens can be avoided to a considerable extent by slight rotation or tilting of the lens. By careful observance of the above-mentioned details, the examination of the normal eye, with the pupil fully dilated by atropine or homatropine, will, with a little practice, give a clear view of the optic disc. When the optic disc has been seen, the patient should be instructed to look directly into the objective lens or at the middle of the surgeon's forehead. This will bring into view the macular region. Examination of the peripheral parts of the fundus is carried out while the patient directs his gaze upwards, downwards, to the right and to the left. Slight lateral displacement of the objective lens in the direction in which the patient is looking will bring into view still more peripheral parts of the fundus. It must be remembered that in this method of examination the position of everything is reversed, so that, for example, if a patch of hæmorrhage is seen apparently above the disc in reality it is below the disc; if it appears above and to the outer side of the disc, in reality it is below and to the nasal side; what appears in the superior region in this method is actually in the inferior region, and so appears in the examination by the direct method. If with the above precautions the disc is still not clearly visible, the surgeon should approach somewhat more closely to the patient. By this method of examination, a general view of the disc, macular region, and of the whole fundus may be obtained and any gross changes observed. Parallax, as referred to above, is of use also in this method of examination, in that by slight movements of the objective lens from side to side and above downwards, while the optic disc is under examination, differences in height or depth of different parts may be at least suspected. For example, a deep glaucoma cup shows, by this means, parallax of the floor of the



deep cup in relationship with the edge of the cup. Similarly, a swelling of the optic disc, as in papilloedema, may be detected, or at least suspected, by the apparent movement of the curve of a vessel on the summit of the swelling in relationship with a vessel on the fundus peripheral to the swollen disc.

(iv.) **Direct ophthalmoscopy** is carried out by the use of Morton's ophthalmoscope, with a lamp capable of being placed to one side of and somewhat behind the patient's face, or with the electric May ophthalmoscope, in which case no external lamp is required. As stated previously, it is easier to see the fundus with an electric ophthalmoscope for two reasons: first, the difficulty of projecting the light through the pupil by means of the slanting mirror of the ophthalmoscope is obviated; secondly, the electric ophthalmoscope, by the ingenious arrangement of its reflector, makes it easier to avoid the brilliant corneal reflex. Direct ophthalmoscopy is of use, (a) for external examination of the eye, (b) for internal examination. In either case, it is a distinct advantage that the pupil should be dilated, for which purpose homatropine and cocaine drops or lamels should have been administered half an hour previously. Caution should be employed in the use of homatropine in patients over forty years of age, whose pupils are large and do not maintain their contraction on exposure to light, or the anterior chamber of whose eyes is shallow. In such there is danger of the onset of glaucoma by its use. The description of the method which follows refers to the examination of the patient's right eye. It is assumed that the surgeon has approximately equally good vision with each eye, so that he can examine the patient's right eye with his own right and the patient's left eye with his left. If the surgeon has one eye with distinctly defective vision, he can with somewhat increased difficulty examine both the patient's eyes with one of his own, *e.g.*, if the surgeon use his right eye, he will examine the patient from his right side. He will examine the right eye in the ordinary manner (to be described) and the left eye by leaning somewhat across the patient, so that the long axis of his face is at right angles to the patient's face.

(a) *External Examination.*—The surgeon sits or stands on the right side of the patient; the lamp, in the case in which Morton's ophthalmoscope is used, is placed level with the patient's eye, slightly behind the right ear, and a little to the right-hand side of his head (Fig. 18). If two small mirrors are fitted to the ophthalmoscope the small plane mirror is used in this part of the



examination. By its use a less intense light is directed upon the front of the eye and slight degrees of opacity are more readily detected. A more satisfactory illumination is also obtained if the unfrosted side of the lamp be used as the source of light. In order to find the right position into which the mirror should be rotated, the beginner will find it advantageous to note by trial, before looking through the ophthalmoscope, the direction in which the light is projected by the mirror in different positions. He will then find that (i.) if the lamp is on a horizontal level with the patient's eye, (ii.) if he holds the ophthalmoscope vertically, (iii.) if the plane of the ophthalmoscope is parallel with the plane of the patient's face as far as possible, the mirror will need to be



FIG. 18.—Direct ophthalmoscopy. The surgeon is seated on the patient's right hand. The lamp is behind and to the right side of the patient's head.

directed in a vertical plane and facing towards the patient's right (see Fig. 18). If the mirror be rotated slightly in a downward direction the light will be directed downwards from it, or if the mirror be directed slightly upwards the light will be directed upwards. Briefly, the plane of the mirror should face the light. The position of the lamp and the mirror will have been arranged as directed, the patient instructed to look directly forwards, the + 20 dioptré lens arranged in the ophthalmoscope in front of the aperture of the small plane mirror (a small concave mirror can be used, but, as stated, the plane mirror is preferable for the detection of slight opacities). The observer, with his eye placed as closely as possible behind the aperture of the ophthalmoscope mirror, approaches the patient while directing the beam of light on to the front of the eye. As he approaches he will find that at a certain point the cornea will be in focus, and any



opacities in it will appear as dark markings against the red of the fundus reflex seen through the dilated pupil. These dark opacities, it should be remembered, appear white or grey on examination by oblique focal illumination, as described above. It is sometimes the case that, by this method of examination of the cornea, the most minute and delicate changes are visible, which are not detected by oblique focal illumination and examination with a magnifying lens. As the ophthalmoscope is approached still more closely to the patient's eye, the iris will become accurately focussed, and any abnormalities in its pattern or colour noted. At the same time, opacities on the anterior surface of the lens will become visible, again as dark markings against the red ground of the fundus reflex. At the same time, opacities in the deeper parts of the lens will become visible. Opacities in the cornea should be examined for parallax, although this is difficult to observe in such a structure which is approximately only 1 mm. in thickness. If a spot of opacity is suspected to be on the deep surface of the cornea, slight movement of the head with the ophthalmoscope from side to side may disclose an apparent movement between the opacity and any small spots which move slowly across the cornea, such as bubbles in the lacrymal secretion or grains of dust. It is a much easier method to determine by parallax whether an opacity is situated in the cornea (in any of its layers) or, alternatively, in the lens. Take, for example, a case in which there is an opacity in the centre of the cornea and an opacity on the anterior surface of the lens in the centre of the pupil. If the observer's head move slightly downwards with the ophthalmoscope while care is taken that the light is directed by the ophthalmoscope mirror a little more in an upward direction so that the red reflex is still clearly obtained, during this movement the opacity in the cornea will appear to move upwards relatively to the pupil margin. The opacity in the centre of the pupil will appear to remain stationary in the centre of the pupil. If, now, an opacity were present at the posterior pole of the lens, as the observer's eye was moved downwards, that opacity would appear also to move downwards, and would eventually disappear behind the lower pupil margin. Briefly, then, opacities in the cornea appear to move in the opposite direction to the movement of the observer's eye; an opacity on the front of the lens, that is, in the plane of the iris, will appear to maintain its position relative to the pupil margin, while an opacity on the posterior surface of the lens will appear



to move in the same direction as the observer's eye (see Fig. 16). If it be found difficult to keep structures in focus with the use of a + 20 dioptré lens, a commencement can be made with a + 12 dioptré lens. To examine the anterior portion of the vitreous by this means, a + 12 or + 10 dioptré lens is used. If the patient be instructed to look to the right without moving his head and to look back straight in front of him, coarse opacities, referred to as floating opacities in the vitreous, are readily detected. The opaque spots or lines or masses swing rapidly with the movements of the eye, and, after the eye comes to rest, the opacities continue to swing a little in the same direction and then swing backwards slightly. Extremely fine dust-like opacities of the vitreous can often only be detected by examining the eye in such a direction that the whiter light reflected from the optic disc is in line with the pupil. Against this whiter light very minute opacities can be detected. In searching for these it is well to alter the strength of the lens in the ophthalmoscope aperture from + 12 to + 8 by stages, while instructions are given to the patient to move his eye between each change. Relaxation of the observer's accommodation is an advantage in examination by direct ophthalmoscopy when the external structures are examined, but it is almost essential for the satisfactory examination of the fundus of the eye. In order to cultivate the ability to relax the accommodation, the observer should use his ophthalmoscope to examine, with a + 12 or + 20 dioptré lens, very small print or other small objects in a good light. He will find that by active use of the accommodation he will be able to keep small letters in focus for a variable distance from the object examined. By approaching more closely to the object greater accommodation is required. In moving the object further away the accommodation must necessarily be relaxed in order that it remain clearly focussed. In order, therefore, to exercise this very necessary relaxation of the accommodation, the observer should move the object as far away as possible from the ophthalmoscope.

(b) *Internal Examination.*—As stated above, the view obtained of the fundus by this method of examination is such that the image is erect. The magnification obtained is approximately of fifteen diameters. If Morton's ophthalmoscope is used, it should be employed as described in section (a) above, but with no lens in front of the aperture if the patient is emmetropic. The rays of light reflected from the fundus of the eye in an emmetropic person are refracted by the cornea and lens within the eye, so as



to emerge parallel. If the observer's eye is also emmetropic or is made emmetropic by the use of correcting lenses as spectacles, these parallel rays entering his eye will be refracted so as to be brought to a focus on his retina. If the patient's eye be hypermetropic the rays will be slightly divergent on emerging from the cornea, and in order that they may be brought to a focus on the observer's retina, either an effort of accommodation will be required on his part, or the presence of a plus or convex lens in the ophthalmoscope. In the case of a hypermetrope, trial can be made by rotating the wheel of the ophthalmoscope so as to place a plus or convex lens in front of the ophthalmoscope aperture, increasing in strength until the optic disc is seen in focus. In the case of a myope, the rays emerging from the eye will be slightly convergent, and will, therefore, require a minus or concave lens in the ophthalmoscope. Otherwise it will be impossible for them to be brought to a focus on the observer's retina (see p. 66). As in the examination of the fundus by indirect ophthalmoscopy, so in this case the first object to be examined should be the optic disc. If the patient's right eye is under examination, this should be made to look somewhat to the left, actually about 15 degrees to the left of the antero-posterior vertical plane. The patient should be instructed to look into the distance in this direction, so that his accommodation may be relaxed. The observer should now look directly along the antero-posterior vertical plane into the patient's eye, remembering that his own accommodation must also be relaxed. If at once the lighter colour of the optic disc is not seen, a slight change of direction of gaze should be made in all directions until a change in colour is observed. The diffuse bright red colour of the red reflex will show a certain amount of pallor when the optic disc comes in the line of view. When this pallor is noticed, if no details of vessels can be detected, a change of lens should be made in the ophthalmoscope, first starting with + 1 sphere and working upwards for several dioptries, and if no improvement takes place a reversal to minus spheres should be made. When the optic disc is clearly seen, the following points should be noticed (see Fig. 123, p. 188): Its colour, whether of a redder hue than normal, or paler; the margin of the disc, as to its definition; the condition of the vessels, and the plane of surface of the disc, that is to say, whether it is depressed below the surface of the surrounding retina or whether it is prominent and projecting in front of the retina. Parallax is of great importance in connection with the plane of surface of the disc. In the study



of parallax, it is wise to observe some particular vessel arching out from the centre of the disc. Slight movements of the head and ophthalmoscope from side to side or up and down will give an apparent movement of this arching vessel relative to the margin of the disc. The arching vessel will move with the movement of the head if the disc is deeply cupped, or against the movement of the head, that is, in the opposite direction, if the disc is swollen and prominent as in papillœdema. After the completion of the study of the disc the surrounding fundus should be examined, and particularly the region of any abnormality noted and approximately localised by indirect ophthalmoscopy; the retinal vessels around the disc, their size, tortuosity, lumen, brightness of the light reflex from their surface—particularly in the case of retinal arteries—the presence of white sheathing on either side of the vessel, the presence of arterio-sclerosis as evidenced particularly by nipping or narrowing of a retinal vein where an artery crosses it, the colour of the fundus, the presence or absence of œdema or white exudate, pigmentations or hæmorrhage on or in the retina. Lastly, the macula itself should be examined by instructing the patient to look directly into the light of the ophthalmoscope mirror. Commonly the macula is evidenced by a gradual increase in the depth of colour, greatest at the fovea itself. In the very centre of this darker area is usually seen a bright spot or triangular-shaped area of light, which moves as the surgeon's head and the ophthalmoscope are moved. This is the light reflex thrown back by the depression of the fovea, which acts as a concave mirror. Delicate changes and fine detail at the macula are usually seen more clearly when the small plane mirror is used. The main differences between the view obtained by indirect and direct ophthalmoscopy are as follows: Indirect—larger field of view, that is to say, a larger area of fundus is visible; the image is inverted; any error of refraction of the patient is of little consequence as far as the method of examination is concerned; the illumination is better, and therefore there is usually a greater visibility of the fundus through opacities of the cornea or lens. Direct ophthalmoscopy—the image is erect; the magnification is higher, therefore, there is greater detail; evidence is obtainable of the type and, to some extent, the degree of the refractive error of the patient's eye if this is not emmetropic. There is great variation in the type of fundus in people of dark or fair complexion. A comparison should be made of the illustrations representing a normal fundus, a fundus of albinotic type (between these two, all



gradations are found in persons of fair type), and, thirdly, the tessellated fundus of the dark complexioned, in which the red ground of the fundus is broken up into a mosaic of darker patches. The fundus of the negro is much more deeply pigmented, owing to increase in the amount of pigment in the pigment epithelium and in the choroid.

(v.) **Transillumination.**—Examination of the eye by transillumination is the investigation of the translucency of the coats of the eyeball. It is carried out by means of a transilluminator or transilluminating lamp. In its simplest form a transilluminator consists in a small electric bulb enclosed in a narrow opaque tube. The lamp is supplied with current, either by a dry battery—as in the case of an electric ophthalmoscope with an adapter for transillumination (viz., Hamblin's electric ophthalmoscope)—or from the main through a resistance. By the application of the luminous end of the tube to the sclerotic of a cocaineised eye, light normally enters the eye, and is seen as a diffuse red glow through the pupil, which should be fully dilated. By the application of the transilluminator to different parts of the sclerotic from the limbus back as far as possible, while the eye is in different positions, a considerable area of the eye is transilluminated. If in one part, over which the instrument is applied, there should be a pigmented new growth of the choroid, the brilliancy of the red glow would be diminished or a definite dark area would be detected.



## CHAPTER II

### REFRACTION AND ACCOMMODATION

#### LENSES

THE lenses used in ophthalmology are of three different types, spheres, cylinders and prisms.

- (1) **Spheres.**—These are convex and concave, and are graduated according to the reciprocal of their focal length in metres, a plus sign indicating a convex lens and a minus sign a concave. The unit for measurement is the dioptré (D), and a lens of 1 dioptré has a focal length of 1 metre, a lens of 2 dioptrés a focal length of  $\frac{1}{2}$  metre, and so on.

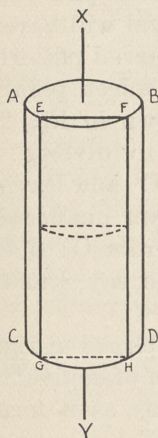


FIG. 19.—ABCD, solid cylinder of glass; EFGH, portion cut off to form convex cylindrical lens; XY, axis.

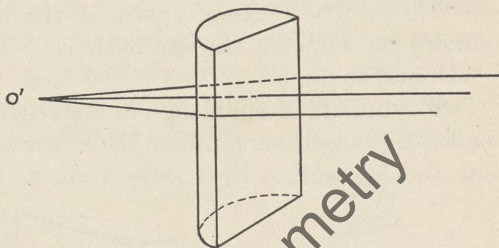


FIG. 20.—Path of parallel rays undergoing refraction by convex cylindrical lens. O' is the principal focus.

The expression sph.—4.0D would therefore indicate a concave spherical lens of 25 cm. focal length.

The dioptré is also used in another way, in measuring the power of accommodation of the eye. Thus, supposing an emmetropic eye when fully accommodated can just see clearly at 25 cm. the eye is said to be accommodating 4D. An eye at rest which sees clearly objects at 25 cm. has acquired 4D of myopia, and could see things clearly at the distance with a lens of — 4D.

- (2) **Cylinders.**—(a) *Convex.*—Take a solid cylinder of glass ABCD, and let XY represent its axis (Fig. 19); now imagine a portion cut by the intersection of a plane EFGH parallel to the axis.



Such a portion would represent a convex cylinder, as used in ophthalmic work. It would have a plane surface posteriorly, while in front it would be curved in the horizontal meridian but not in the vertical. It would therefore affect parallel rays of light in the way shown in Fig. 20, bringing a horizontal beam to focus at, say,  $O'$  and not affecting the direction of a vertical beam. If the distance of  $O'$  from the cylinder is 1 metre the strength of the latter is 1D, if  $\frac{1}{2}$  metre 2D, and so on.

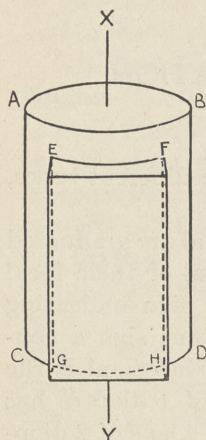


FIG. 21.—To show formation of concave cylindrical lens.

(b) *Concave*.—Take the same cylinder of glass, but imagine that a transparent mould EFGH is applied to its front surface (Fig. 21). Such a mould on removal will have a plane anterior surface and a curved posterior surface. It would therefore affect parallel rays of light in the way shown in Fig. 22, causing a horizontal beam to diverge as though it came from a point  $O'$  and leaving the direction of a vertical beam unaffected. Here, again, if the distance from  $O'$  to the cylinder be 1 metre the strength is  $-1D$ , if it be, say,  $\frac{1}{4}$  metre  $-4D$ , and so on.

Two cylinders of equal sign and strength, when placed at right angles to each other, produce the effect of a sphere of equivalent sign and strength. It is important to realise this, as it forms

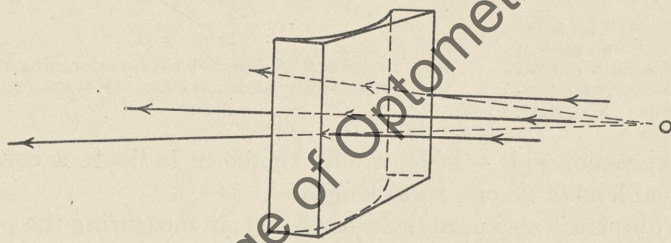


FIG. 22.—Path of parallel rays undergoing refraction by concave cylindrical lens.  $O$  is the principal focus.

the basis for writing prescriptions for lenses in spectacles (*vide* p. 56).

(3) **Prisms**.—A ray of light passing through a prism is deflected along the path ABCD, as shown in Fig. 23, where A is the source of light. Imagine the eye of an observer placed at D, the observer, not realising this deflection, will project the image of A along the



line of DC and it will appear to him as though it were at A'. A prism will thus be seen to cause apparent displacement of objects towards its apex. It is for this purpose that prismatic lenses are used in glasses.

The notation of prisms is not quite so satisfactory as that of lenses, since there are at present at least three systems in vogue. It will suffice to mention two of these. The first consists in

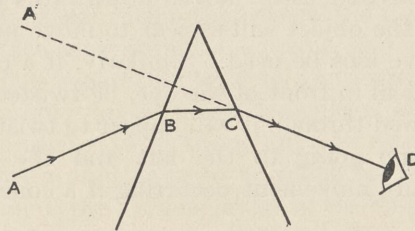


FIG. 23.—Path of rays through a prism. D, observer's eye; A, object; A', apparent position of object.

measuring the apical angle and describing the prism as being one of so many degrees in strength. The objection to this system is that not all glass possesses the same refractive index, and that a prism of, say,  $2^\circ$  in crown glass would give a different effect from one of the same angle made of flint glass. It is therefore more satisfactory to calibrate a prism according to the effect it produces, and for this reason the prism dioptre system has been introduced, a prism of dioptre (written  $1\Delta$ ), causing an

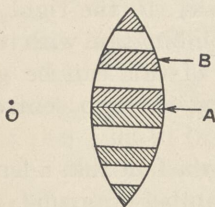


FIG. 24.—Convex lens, split up into prisms.

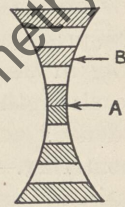


FIG. 25.—Concave lens, split up into prisms.

object 1 metre away to be apparently displaced 1 cm., one of  $2\Delta$ , 2 cm., and so on. It so happens, however, that with the small prisms commonly used in glasses, the two systems are practically identical, a prism of  $3^\circ$  being approximately the same as one of  $3\Delta$ . On the other hand, a prism of  $3^\circ$  made with the usual glass causes a deviation of only  $1.6^\circ$ , so that if any one is overcoming a prism of  $25^\circ$  base out, he is not converging through an angle of  $25^\circ$ , but of one a little over  $14^\circ$ .



A lens may be considered as made up of an infinite number of small prisms, the central pair having their bases in apposition for a convex lens and their apices in apposition for a concave one (*vide* Figs. 24 and 25). Thus an observer looking through A would see no apparent lateral displacement in the object O. On looking through B, however, the object would appear displaced upwards in a convex lens and downwards in a concave one. It will thus be seen that if a convex lens be moved downwards (or the observer move upwards) the object will appear to move upwards and *vice versa* if a concave lens be used. Similarly, if a convex cylinder, placed axis vertical in front of the eye, be twisted to the right, a vertical line viewed through it will appear to twist in the opposite direction, the top going to the left and the bottom to the right, the opposite movement occurring if a concave cylinder be used.

By these means it is possible to tell what type or types of lenses are present in a pair of spectacles. The strength is estimated by placing, in front, neutralising lenses of opposite signs until all apparent movement of objects is abolished. To find out whether a prism is also incorporated in the spectacle lens under examination, it is necessary to find its optical centre. This is done by holding the lens in front of two cross lines and moving it about until an unbroken line passes through the lens in both directions. The point where the lines intersect represents the optical centre of the lens. If this coincides with the geometrical centre there is no prism, but if the former be, say, to the right of the latter, a prism will also be present in the combination with its apex pointing in this direction. The strength of this can be gauged by the strength of prism required to bring the two centres into coincidence.

**Decentering.**—Practical use is made of the fact that a lens may be considered as composed of an infinite number of prisms. It has already been explained how, if the eye is looking through a part of the lens some distance from its optical centre, a prismatic effect is produced and it is found that if the lens of  $n$  dioptries be de-centred  $m$  centimetres, it gives the effect of adding a prism of  $nm$  prism dioptries, the apex of the prism pointing towards the thinnest part of the lens. Thus, if it were required to produce the effect of a prism  $2\Delta$  apex in before the right eye with a convex lens of 6D, it would suffice to decentre it a  $\frac{1}{3}$  cm. outwards. The application of this method is very limited as it is seldom possible to decentre a lens more than a few millimetres.



## OPTICAL STRUCTURE OF THE EYE

Before passing on to consider the refraction of the eye it is necessary to know something of its optical structure.

The eye as an optical instrument may be described as resembling a box camera, except that the lens system is more complicated. There are the following *surfaces at which refraction takes place* :—

- (1) The anterior surface of the cornea.
- (2) The surface separating the cornea and aqueous.
- (3) The surface separating the aqueous and lens.
- (4) The surface separating the lens and vitreous.

In addition, to give an accurate description of what happens to a pencil of parallel rays in traversing the refractive media of the eye, allowance would have to be made for the difference in index of refraction of the various layers of the lens. In general, it is found that the central portions of the lens have a higher refrac-

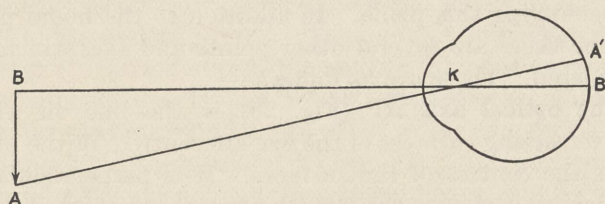


FIG. 26.—AB, object ; K, nodal point ; A'B', retinal image.

tive index than the peripheral portions, the figures being 1.388 for the outer layers and 1.411 for the nucleus. In actual practice no very serious error is involved if we regard the optical system of an emmetropic eye as equivalent to a single lens whose nodal point is 15.8 mm. in front of the retina, the strength of the lens being such that it brings parallel rays to a focus on the retina. This nodal point lies just within the posterior layers of the cortex of the lens—a matter of some importance in the diagnosis of the site of small cataracts. Having reduced the eye to this simple lens system, it is now an easy matter to draw a diagram (Fig. 26) of an object forming its image on the retina. As K is the nodal point of the eye, rays of light will pass through it without any change in direction. AKA' therefore represents the path taken by those rays of light passing from the lower end of the object through the nodal point to the retina, and BKB' those passing from the top of the object. Such a diagram shows us the position and size of the retinal image, but it does not tell us whether it is sharply defined.



To discover this, a construction such as that shown in Fig. 27 is necessary, in which  $AB$  is the object,  $A'B'$  the image,  $K$  the nodal point,  $CD$  a single lens representing the optical system of the eye,  $BB'$  the optical axis, and  $F$  the posterior principal focus of the lens system of the eye. Then the line  $AC$  drawn parallel to the visual axis will, after refraction, pass through  $F$ , while  $AK$  will continue without any change in its direction. The point  $A'$ , where these two lines meet, indicates the position of the image of  $A$ , and

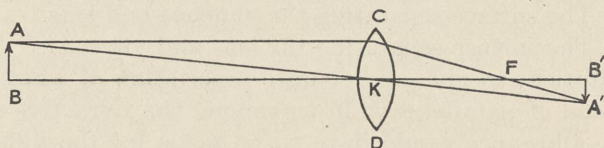


FIG. 27.—Refraction by convex lens.  $AB$ , object;  $K$ , nodal point;  $F$ , principal focus;  $A'B'$ , image.

$A'B'$  the position and size of the retinal image, in the event of the retina occupying this plane. In addition to the nodal point and visual line there are several other points and axes which have to be considered. These are as follows:—

(1) **The optical axis**  $AP$  (Fig. 28) is the line on which the various refracting surfaces of the eye are centred, or the line which connects the centres of the surfaces. It is perpendicular to the cornea, where it pierces the latter and it passes through the nodal

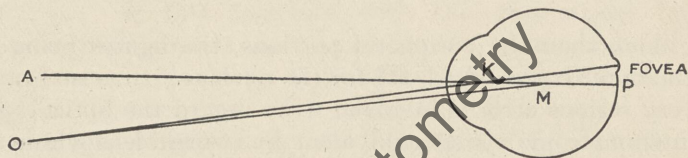


FIG. 28.—Horizontal section of right eye, viewed from above.  $AP$ , optical axis;  $K$ , nodal point;  $M$ , centre of rotation of eye;  $O$ , object; Angle gamma,  $AKO$  or  $AMO$ .

point. It will be seen in Fig. 28 to pass somewhat to the nasal side of the fovea.

(2) **The visual line** connecting the fovea, the nodal point, and the object ( $o$ ) viewed by the eye. This line usually passes through the pupil somewhat to its inner side instead of through the centre.

(3) **The fixation line**  $OM$  joining  $M$ , the centre of rotation of the eye, and  $o$  the object.

There is a certain amount of confusion as to nomenclature of the angles between these various lines. In general, however, as



the visual line and the line of fixation so nearly coincide, the angle AKO is taken as the angle gamma ( $\gamma$ ), though according to definition it is AMO. The angle kappa ( $\kappa$ ) is the angle between the fixation line OM and a line drawn through the centre of the pupil, perpendicular to the cornea. It again is nearly equal to  $\gamma$  but not quite, because the centre of the pupil is a little to the inner side of the centre of the cornea. In practice this angle is the one which is measured and regarded as being  $\gamma$ . The main point of these observations is that the visual line does not usually coincide with the apparent direction of the eye, and it is therefore possible for the two eyes to appear to have a squint when actually they are both fixing the same object.

*In order to measure the angle  $\kappa$*  the patient is directed to place his chin on the chin support of a perimeter and to fix his gaze on the central dot. A candle flame is then moved round the arc of the perimeter until the observer, whose eye is in line with the flame and the patient's eye, sees the corneal image of the light in the centre of the patient's pupil. The number on the arc opposite the candle gives the amount of the angle  $\kappa$ , which is usually  $5^\circ$ .

An emmetropic eye is one which, with the accommodation at rest, is focussed for infinity. In other words, the retina in such an eye would lie in the plane of F (Fig. 27). An emmetropic eye at rest therefore could not obtain a sharp image of AB; to do so it would have to shorten its focal length so as to bring F and A'B' further forwards, and cause the image A'B' to lie in the retinal plane. This act is known as **accommodation**, and is brought about as described on p. 149.

**Presbyopia** consists in a gradual loss of the power of accommodation. The curve shown in Fig. 29 gives the results obtained by Duane in the investigation of a large number of cases. This loss is due to a gradual sclerosis which occurs in the lens during life, and diminishes its elasticity, so that the older an individual becomes the less change there is in the shape of the lens when the tension on it is relaxed. It will be seen from the curve that by the time a normal individual has reached the age of forty-five he has only 3.5D of accommodation. If emmetropic he can, by exercising nearly the whole of his accommodation power, just succeed in reading at 33 cm. (the usual reading distance). This strain, however, cannot be kept up for long, and the patient therefore requires reading glasses. If he is given a + 1 sph. in front of each eye he will have to use only 2D of accommodation to read at 33 cm., having 1.5D in reserve, and with this he will in all probability be



quite comfortable. At the age of fifty the normal accommodation is only 1.9D, so that he will require a reading glass of sph. + 2.0D, which will leave him a reserve of 0.9D. It is usually found for reading, that a glass is required of such strength that it will leave the patient approximately a third of his total amplitude of accommodation in reserve.

**Premature Presbyopia.**—This description has been given to cases of failure of accommodation. Apart from third nerve palsies,

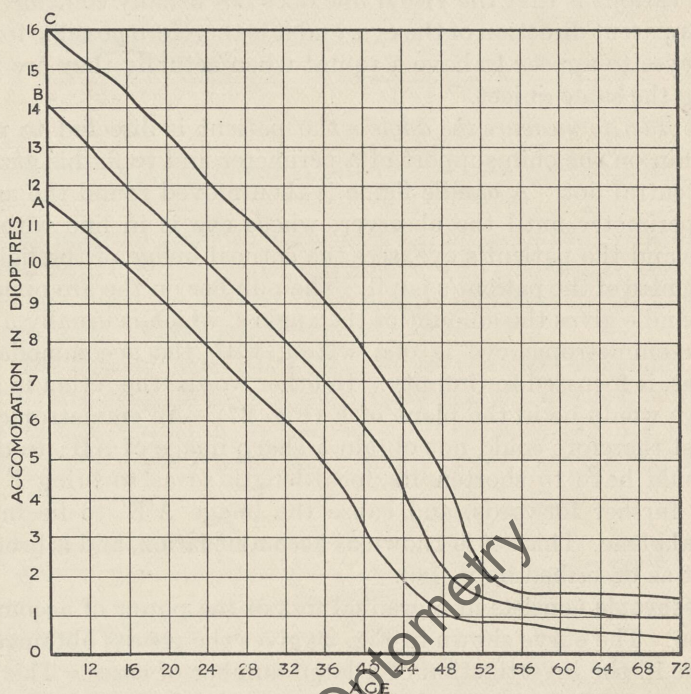


FIG. 29.—Curves showing amplitude of monocular accommodation at different ages. A, the lowest physiological values; B, the medium; C the maximum. (Reproduced by kind permission from Fuch's "Text-book of Ophthalmology.")

such as occur in diphtheria, influenza, lethargic encephalitis, cerebral tumour, etc. It is found in the following conditions:—

- (1) Prolonged residence in the tropics, owing to premature sclerosis of the lens induced by exposure to the sun.
- (2) Habitual constipation and toxic states generally, which again bring about early lens sclerosis.
- (3) In glaucoma, probably from pressure effects on the ciliary muscle or the nerves supplying it.



(4) It may be present in myopes of a certain degree who have not worn glasses as they have never had any need to accommodate for near objects, and so their ciliary muscles are atrophic.

On the other hand, there may be an apparent diminution of presbyopia in cases of incipient cataract. This is due to an increase in the refractive index of the lens causing myopia, and so ability to see near objects without glasses. The same phenomenon is sometimes observed in diabetes as an index of commencing lens change.

**Hypermetropia** is that condition of the eye in which a beam of parallel rays is brought to a focus at a point behind the retina (*vide* Fig. 30). This may be due to several causes.

(1) The eye may be too short, but otherwise normal. The condition is then known as *axial hypermetropia* and is the form of defect most commonly found. In fact it is almost universal in children, since the eye tends to grow in length in the same way as

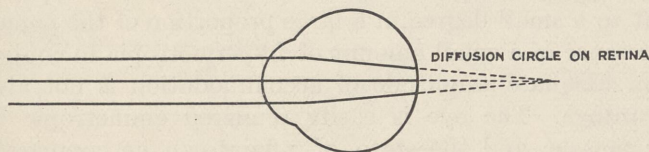


FIG. 30.—Parallel beam of rays undergoing refraction in hypermetropic eye. (Note for simplicity, drawings are those of the reduced eye therefore corneal refraction is not shown.)

growth occurs in other parts of the body, so that if the child is not to be myopic when he grows up he will almost certainly be hypermetropic when young.

Another form of axial hypermetropia is due to pathological shortening of the visual axis of the eye and occurs: (a) In cases where a neoplastic or inflammatory mass occupies the orbit, pushing the eye forwards from behind and shortening its antero-posterior axis. A useful indication of increase or decrease in the size of the mass may frequently be afforded by alterations in the refraction of the eye. (b) In cases where the retina is protruded forwards by inflammatory exudate or new growth. Such a condition is commonly found in cases of glioma exophytum, where the retina may even be in contact with the posterior surface of the lens.

Extreme degrees of axial hypermetropia occur as developmental anomalies when the eye is abnormally small. In some cases this condition is associated with a defect in closure of the optic cleft, so



that a cyst-like protrusion of the optic vesicle is formed below the microphthalmic eye.

(2) *Curvature Hypermetropia*.—The length of the eye may be normal but the refracting media or surfaces abnormal, so that the rays of light are not bent sufficiently to meet at the retina, *e.g.*, the cornea may be insufficiently curved. This may occur as a congenital condition (cornea plana) or be due to cicatricial contraction following loss of substance by ulceration, etc.

(3) *Index Hypermetropia*.—The refractive index of the lens may be abnormally low—a condition occasionally occurring in diabetes—or the lens may be placed abnormally far back owing to trauma, developmental defect or disease. Again, the lens may be dislocated out of the pupillary area or be absent altogether. In this case a high degree of hypermetropia may be produced (about 10D in a previously emmetropic eye), and the power of accommodation is completely abolished.

Axial hypermetropia is by far the commonest type, and is present to a small degree in a large proportion of the population. The presence of a small amount of hypermetropia in conjunction with an adequate amplitude of accommodation is not always a disadvantage. The eye is easily rendered emmetropic by the ciliary muscle, and the state of affairs can be compared with that in which an observer is looking down a microscope with his finger on the "fine adjustment."

COURSE OF HYPERMETROPIA.—Hypermetropia, originally present at birth, tends to diminish steadily in amount up to the age of twenty. This is due to increase of length of the eye occurring as one of the phenomena of growth, and it may lead to the conversion of hypermetropia into myopia. The changes occurring after the age of forty-five or so are somewhat variable. As a rule the lens becomes more homogeneous, and so of lower refractive power, in consequence of which the eye tends to become more hypermetropic or less myopic. Occasionally, however, a moderate amount of myopia may develop, due to increased sclerosis of the lens nucleus or to incipient cataractous changes.

VARIETIES OF HYPERMETROPIA. — It has already been explained—

- (i.) That accommodation has the effect of shortening the focal length of the lens system of the eye.
- (ii.) That a hypermetropic eye is one in which parallel rays are brought to a focus behind the retina.

It is therefore obvious that hypermetropia up to a certain



amount may be overcome by accommodation, and that a young hypermetrope, with a fair amount of accommodation, may do this unconsciously, owing to the inherent tone of the ciliary muscle. In cases such as this there will be a difference between the amount of hypermetropia present when the ciliary muscle is paralysed by a cyclopegic and when it is not so paralysed. This difference is known as *latent hypermetropia*, the amount present when the ciliary muscle is not paralysed being called *manifest hypermetropia* and the sum of the two, *total hypermetropia*.

**SYMPTOMS OF HYPERMETROPIA.**—In the absence of accommodation, a hypermetrope would have indistinct vision both for distant and near objects. The question as to whether he sees clearly in the distance depends therefore on the ratio between the amplitude of his accommodation and the amount of his hypermetropia. It is for this reason that a man of, say, fifty, with 2D of hypermetropia, requires glasses for distance as well as for reading, whereas

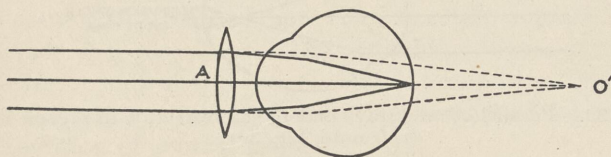


FIG. 31.—Eye in Fig. 30 corrected for hypermetropia.  $AO'$  = focal length of correcting lens (*vide* note, Fig. 30).

when he was twenty he required them only for reading. The effect on near vision is best explained by taking a hypothetical case, such as the one already mentioned. The usual reading distance is  $\frac{1}{3}$  metre. An emmetrope, in order to read at this distance, will have to exercise 3D of accommodation and finds no difficulty in doing so, provided he has not reached the age of presbyopia. A hypermetrope of, say, 2D, however, will have to overcome his hypermetropia as well, and will therefore have to accommodate 5D. He may succeed in doing this for a short time, especially when young, but eventually the added strain on the ciliary muscle will cause headache and a feeling of strain in the eyes, as his amplitude of accommodation is no greater than that of an emmetrope of the same age. Later on, in addition to headache and tiredness, he will notice that the print becomes blurred, and eventually it becomes impossible to read, if the effort is attempted for any length of time. It is thus evident that a hypermetrope will require glasses for reading at a younger age than an emmetrope, and that the greater the amount of hypermetropia the earlier will



the glasses be required. This condition must not be confounded with presbyopia, since the glasses are ordered only for the sake of rendering the eye emmetropic and not to make it artificially myopic, as in the case of presbyopia. Reference to Fig. 31 may possibly make this clearer.

In practice one frequently finds that hypermetropes, especially if there is any astigmatism, are more comfortable when wearing glasses constantly, the same lenses being used for distance and reading until the onset of presbyopia.

In addition to the symptoms of hypermetropia, there are various signs which are also seen in astigmatism and will be described under that heading.

**Myopia** may be defined as that condition of the eye in which a beam of parallel rays is brought to a focus at a point in front of

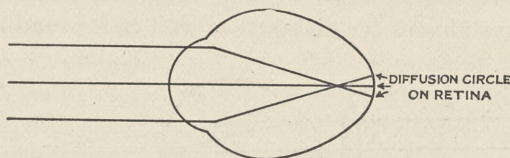


FIG. 32.—Parallel beam of rays undergoing refraction in myopic eye (*vide* note, Fig. 30).

the retina (*vide* Fig. 32). Just as in hypermetropia, this may be due to several causes :—

(1) The length of the eyeball may be too great—*axial myopia*. This, as already explained, is usually an acquired condition, but it may be present at birth.

(2) *The curvature* of the refracting surfaces may be too great. Thus : (a) The anterior surface of the cornea may be more highly curved than normal, a condition which can be diagnosed by the ophthalmometer ; and (b) The lens may be more curved than normal, as occurs physiologically during the act of accommodation or pathologically in the condition of posterior lenticonus.

(3) The index of refraction of the lens may be abnormally high, as in incipient cataract and some cases of diabetes, and in axial myopic degeneration of the lens. This condition is called *index myopia*.

Again, as in hypermetropia, the axial type of the defect is by far the commonest.

**COURSE.**—It has been estimated that only 5 per cent. of the population are myopic at birth, whereas at sixteen a much larger proportion of children are myopic. Myopia is thus in most cases



an acquired disease, and if the child is born myopic the defect tends to increase with age. This defect is, in the majority of cases, discontinuous, *i.e.*, it may remain of the same amount for one or two years. Myopia developing during childhood is the result of two antagonistic processes going on at the same time :—

(1) Progressive flattening of the abnormally curved infantile lens.

(2) Growth in length of the eye.

In the majority of instances myopia does not exceed 8D or 9D and ceases to increase to any degree after the age of twenty-six, when growth is complete. There is another type of myopia, fortunately somewhat rare, but of great clinical importance, since it may lead eventually to almost complete blindness. In this type, known as progressive myopia, the defect is usually high even during adolescence, when it may be 10D or more. It gradually increases during life till it may reach more than 30D. This increase is due to progressive stretching of the sclera, and as the retina cannot be stretched more than a certain amount it becomes degenerate and may tear. The stretching occurs principally in the posterior half of the eye, so that the important macular portion of the retina is involved, resulting in marked deterioration or even abolition of central vision.

ÆTIOLOGY.—This has been the subject of numerous investigations, and the following are among some of the theories put forward :—

(i.) That there is an inherited weakness of the posterior part of the sclera causing it to stretch unduly before the intraocular pressure. A point in favour of this is the marked hereditary factor in myopia.

(ii.) That there is congenital weakness of the ciliary muscle, which interferes with its "pump action" (*vide* glaucoma), thus causing diminished excretion of aqueous and a rise in intraocular pressure, this rise bringing about distension of the posterior pole of the eye. Once this has occurred and the eye become myopic the ciliary muscle is not used for accommodation and the process tends to go on. It is found that the progress of myopia is usually retarded by the wearing of adequate glasses, which cause the patient to exercise his ciliary muscle in doing near work and so restore its pump action.

(iii.) That it is due to excessive near work. Thus statistics are cited showing how myopia is common among jewellers, type-setters, etc., whereas it is practically unknown among savages.



Several criticisms may be directed against this, *e.g.*, that a myope would naturally choose some form of close work because it is so easy for him, and that a myopic savage would stand little chance of survival.

(iv.) That an uncorrected myope in doing close work will tend to hold it nearer than an emmetrope and thus will exercise a higher degree of convergence. This high degree of convergence causes tension on the extraocular muscles, thus causing increase of intraocular tension, bringing about elongation of the antero-posterior diameter of the eye.

In actual practice it is difficult to escape the conclusion that myopia is in some way connected with excessive close work; on the other hand, not all those who engage on close work develop myopia, so one must assume that there is also an inherited weakness of the sclera, and that this predisposing cause must be present before myopia can occur.

**SYMPTOMS OF MYOPIA.**—Myopes are unable to see clearly at a distance, since the image of a point source of light forms a diffusion circle on the retina (*vide* Fig. 32). Accommodation will only make matters worse by increasing the amount of myopia and making the diffusion circle still larger. A certain amount of improvement in vision can be obtained by partial closure of the eyes, because the effective aperture of the pupil is thereby diminished—a condition comparable with stopping down the lens of a camera. The same effect may be produced by anything which causes a diminution in the size of the pupil. After massage of the eye there is some reflex engorgement of the iris, in consequence of which the pupil becomes temporarily smaller and vision correspondingly clearer. This fact is the basis of some quack “treatment” of myopia without glasses. In near vision the myope has several advantages over the emmetrope.

(i.) Provided his myopia is of sufficient degree he need not accommodate.

(ii.) He obtains larger retinal images in near vision because the distance of the retina from the nodal point is greater than in the emmetropic eye (*vide* Fig. 32).

(iii.) He is able, if necessary, to approximate small print, etc., closer to his eye.

(iv.) He may be able to do without reading glasses even in advanced age.

**ACCOMMODATION IN MYOPIA.**—A myope, unless of high degree, has usually the same amplitude of accommodation as an emme-



trope, though it may not be so well maintained on account of the smaller size of the ciliary muscle, especially its circular portion. The range of accommodation, however, is different, since this latter quantity represents the distance in centimetres between the far point and near point. Suppose that we have three individuals, A., B. and C., of the same age, each possessing 5D of accommodation. Let A. be emmetropic, B., 3D hypermetropic, and C., 3D myopic (*vide* Fig. 33). Then the near point for A. will be  $\frac{100}{5}$  cm., and the range of accommodation will be from infinity to a point 20 cm. from the eye. B.'s near point will be  $\frac{100}{5-3} = 50$  cm., and his range will be from infinity (where he is already using

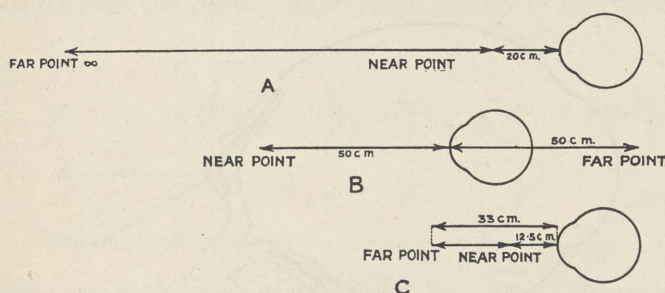


FIG. 33.—Range of accommodation in (A) emmetropia, (B) hypermetropia, (C) myopia.

3D of accommodation) to a point 50 cm. from his eye. C.'s near point will be  $\frac{100}{5+3} = 12.5$  cm. His far point, however, is only  $\frac{100}{3} = 33$  cm., so that his range of accommodation is only  $33 - 12.5 = 20.5$  cm.

In high myopia, near vision may also be interfered with. A myope of 10D, for example, could not, without glasses, see print clearly at a distance greater than  $\frac{100}{10}$  cm. = 10 cm., and the convergence necessary to maintain single vision at this distance may cause discomfort and eyestrain.

SIGNS OF MYOPIA.—(1) Owing to its increased length a myopic eye may be more prominent than an emmetropic one.

(2) The pupil is usually larger and the anterior chamber deeper.

(3) In high myopia there may be iridodonesis (*vide* glossary).



(4) Opacities are frequently present in the vitreous, which may be of fluid consistency. This is because the vitreous becomes degenerate owing to the stretching to which it is subjected.

(5) Fundus changes. These vary in degree according to the amount of myopia present and depend for their production on the stretching of the sclera. In a mild case, all that is seen is a whitish crescent round the temporal side of the optic disc, with possibly a little blurring on the nasal side of the disc (Fig. 34, Plate I.). This is brought about in the following way. The myopic eye tends to elongate in the antero-posterior diameter and the optic nerve joins the eye to the inner side of the posterior pole, *vide* Fig. 35, which represents a horizontal section of the right eye viewed from above. It is obvious that traction in the

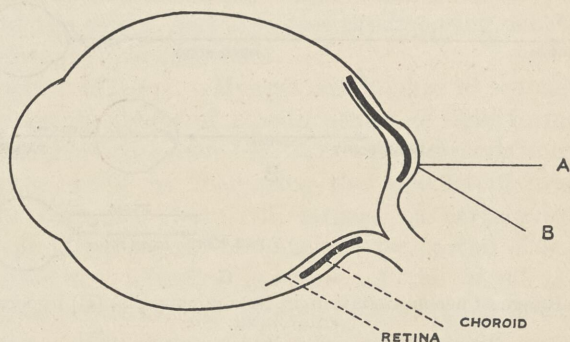


FIG. 35.—Formation of myopic crescent and posterior staphyloma in myopia.

direction of A will tend to drag the retina and choroid away from the temporal margin of the disc, leaving a portion of the sclera (the myopic crescent) showing through the atrophic retina and choroid, while on the nasal side the retina and choroid will be pulled over the edge of the disc, making it appear blurred (supertraction crescent). The higher the myopia the larger this crescent becomes. It also tends to spread round to the nasal side of the disc. In myopia of high degree the protrusion backwards of the posterior part of the sclera becomes more marked, forming in fact, a "posterior staphyloma," the edges of which may be recognised with the ophthalmoscope. Fundus changes now become apparent in other parts, beginning usually in the region between the disc and macula, where areas of rarefaction appear in the choroid. These coalesce later to form large, white atrophic patches, usually involving the macula itself with abolition of central vision (Fig. 36, Plate I.). Owing to



the continued stretching of the retina, hæmorrhages and rents are likely to occur, especially in the region of the macula, and occasionally a black spot develops here. Another complication to which myopes are prone is detachment of the retina (*vide* p. 190).

**Astigmatism** is that condition of the eye in which the refracting surfaces are not spherical, so that a beam of parallel rays is not brought to a common focus. Fig. 37 represents successive cross sections of a circular beam of parallel rays  $axby$  undergoing refraction by an astigmatic lens system, in which the refracting power is higher in the horizontal meridian  $ab$  than in the vertical meridian  $xy$ .

A is the circular beam before refraction.

At B neither set of rays has come to a focus, but  $ab$  is shorter than  $xy$  because the refracting power is greater in this meridian.

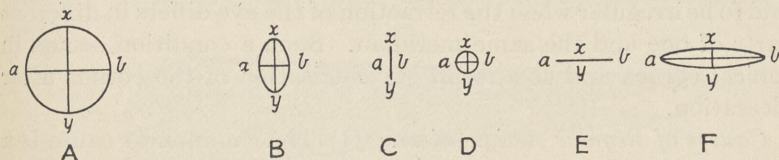


FIG. 37.—Serial cross sections of astigmatic pencil of rays.

The beam, if intercepted at this point by a sheet of cardboard, would therefore be oval.

At C a vertical image is produced because the beam is in focus horizontally but not vertically, though  $xy$  is now shorter than it was in Fig. 37, A. (If there were no astigmatism the image would, of course, be a point.)

At D a circular image is produced, the rays in the plane of  $xy$  being still convergent.

At E a horizontal linear image, because the vertical plane of the beam is brought to a focus while in the horizontal plane the rays are diverging.

At F an oval image, because both sets of rays are now divergent, having passed their respective principal foci, C and E.

This variety of astigmatism is known as regular astigmatism because :—

- (1) The plane of either surface of refraction is spherical, though the radii are unequal.
- (2) The planes are at right angles to each other.

Thus, assuming for the moment that the condition is due to the cornea, the shape of this could be compared with that of the back



of a spoon held vertically. Regular astigmatism is classified as follows :—

(1) *Compound myopic astigmatism*—C and E (Fig. 37) are both in front of the retina.

(2) *Simple myopic astigmatism*—E lies on the retina but C is in front.

(3) *Mixed astigmatism*—C is in front of the retina and E behind.

(4) *Simple hypermetropic astigmatism*—C is on the retina and E behind.

(5) *Compound hypermetropic astigmatism*—both C and E lie behind the retina.

Astigmatism is said to be with the rule when the meridian of greater curvature is vertical and against the rule when it is horizontal. The meridian of greater curvature may, of course, be at any angle, not necessarily vertical or horizontal. Astigmatism is said to be irregular when the refraction of the eye differs in different parts of one and the same meridian. Such a condition occurs in conical cornea and as a result of cicatrization of the cornea after ulceration.

*Causes of Regular Astigmatism.*—(1) The commonest cause is a difference in the curvature of the two meridians in the cornea. This is usually congenital, but may undergo alteration during life. Astigmatism may also be caused temporarily by the pressure of some swelling, such as a Meibomian cyst against the cornea, and it usually follows intraocular operations, such as iridectomy, etc.

(2) Astigmatism may also be caused by the lens.

(a) There may be a difference in curvature of the two meridians on the anterior or posterior surface.

(b) The lens may be tilted as a congenital anomaly or by trauma, or there may be a combination of these two factors.

In early cataract, irregular lenticular astigmatism is of frequent occurrence.

*Symptoms of Astigmatism.*—Mild varieties of astigmatism ( $\cdot 25D$  to  $\cdot 5D$ ) are almost universal, and if of the hypermetropic variety may cause the patient no inconvenience whatever. Sometimes, however, especially in neurasthenia, quite a small amount of astigmatism may be responsible for bad headaches, and even for the neurasthenia itself.

Higher grades of astigmatism cause considerable reduction of visual acuity, since the eye cannot obtain a clear image of an



object unless it is a linear one arranged to point in a certain direction, and then only if the eye is emmetropic in one meridian.

In order to comprehend the subjective phenomena of astigmatism the following points must be borne in mind.

(1) The axis of a cylindrical lens represents its plane surface, and its maximum curvature is, therefore, at right angles to this.

(2) In order to see a line clearly only the borders need be in focus. Fig. 38 represents in perspective, rays of light from a distant linear object coming to a focus at *ab* in an astigmatic eye. From this it is obvious that the eye must be emmetropic in the vertical meridian if a given horizontal line is to be seen clearly. Hence we have the general principle that in astigmatism, if one axis is emmetropic or is rendered so by means of spherical lenses, lines in a direction at right angles to this axis will be seen clearly. This principle is made use of in the subjective tests for

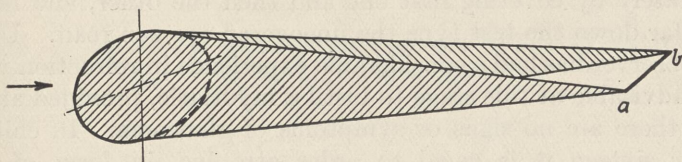


FIG. 38.—View in perspective of astigmatic pencil of rays, coming to a linear focus.

astigmatism and in the measurement of astigmatism with the ophthalmoscope.

To apply these principles, consider what would happen in a case of simple myopic astigmatism of  $-3D$ , the axis of the correcting cylinder being vertical. From (1) (above) the defective meridian in the eye must be horizontal, the vertical meridian being emmetropic. If such an eye, therefore, looked at letter L, the horizontal limb of the L would be seen clearly while the vertical would be blurred. Now imagine we put a  $-3D$  spherical lens in front of the eye; the horizontal meridian would be corrected, while the vertical would be rendered  $3D$  hypermetropic. The eye would now see the vertical limb of the L clearly, while the horizontal would be blurred. Another way of explaining this case is to say that in the first instance ( $-3D$  myopic astigmatism) the condition is comparable with what would occur in Fig. 37 if the retina were at E, and in the second instance at C.

It is thus obvious that patients with astigmatism are unable to see letters clearly, and that accommodation or correction with spherical lenses alone, will not enable them to do so. They are,



however, continually straining their ciliary muscles in an endeavour to obtain distinct vision, and it is this strain which is responsible for the headaches and eyestrain. If the axis of the astigmatism is different in the two eyes, the effect is still more marked.

The objective signs of astigmatism, and usually of hypermetropia, are the occurrence of styes and blepharitis, with conjunctival hyperæmia and an increased susceptibility to conjunctivitis. The effect on production of squint is discussed later.

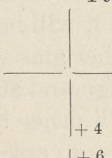
**Treatment of Errors of Refraction.**—The first essential is the correct estimation of the amount of error present, and in order to do this the following procedure may be carried out:—

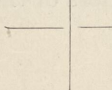
The patient is seated at a distance of 6 metres from a card of standard test type, and the visual acuity measured in each eye separately by covering first one and then the other, and noting how far down the test type the uncovered eye can read. Unless the observer has had a considerable experience in refraction work, it is advisable at this stage to instil a mydriatic, provided always that there are no signs or symptoms of glaucoma. In children under sixteen it is usual to order atropine, in form of ung. atropine 1 per cent. A portion of ointment about the size of a match head is put inside the lower lid of each eye by means of a glass rod every night and morning for three clear days before the next examination. In adults and children over sixteen it usually suffices to instil one drop of homatropine and cocaine hyd.  $\bar{a}\bar{a}$  2 per cent. in castor oil, into each eye, an hour before the examination. The patient is then taken into the dark room and seated in a chair with a light above and slightly behind her head, if the usual form of ophthalmoscope lamp is used (*vide* Fig. 8). It is better to have the unfrosted portion facing the observer, who is seated 1 metre distant from the patient. The observer now places a trial frame on the patient's face, takes a retinoscopy mirror or the large plane mirror of his ophthalmoscope and shines the reflection from it into the patient's eye, directing her to look straight at the mirror. He will observe that her pupil gives out a yellowish red light—the fundus reflex—and, on tilting the mirror, that this reflex appears to move relatively to the pupil. If the movement of the reflex is in the same direction as that in which the mirror is tilted, the patient has hypermetropia or has myopia of less than 1D; if in the opposite direction, she has myopia of more than 1D. In the former event, convex lenses are placed in the




trial frame, and in the latter, concave, until apparent movement in the reflex is abolished. This point is known as the neutralisation point, or point of reversal, because any further increase in the strength of the sphere will reverse the apparent movement of the fundus reflex. The lens required to produce this effect represents the amount of correction required to give the patient 1D of myopia—1D must therefore be added to it to render her emmetropic for distant vision.

In astigmatism, neutralisation will be obtained in one axis before it is obtained in the other, and the strength of lens required must be separately estimated for each of the two axes. Moreover, the shape of the fundus reflex will become barlike when near the neutralisation point, the long and short axes of the "bar" corresponding with the axes of the astigmatism. The result of the retinoscopy is recorded in the following manner :—

(1)  + 4 would represent the result of examining a hypermetrope of 3D.

(2)  + 4 would represent the result of examining a patient with 3D of hypermetropia, and 2D of hypermetropic astigmatism, axis

horizontal. The figure indicates that neutralisation was effected in the horizontal meridian with a spherical lens of + 4D, while in the vertical meridian it required a lens of + 6D.

(3)  - 2 would represent the result obtained in a case of mixed astigmatism with oblique axes where one is myopic and the other hypermetropic.

DIFFICULTIES IN RETINOSCOPY.—These are three in number :—

(1) The presence of irregular astigmatism causes distortion of the fundus reflex with all sorts of movements in it on tilting the mirror. With experience a fairly correct estimate may be made of the best lenses for the patient, but these cases are always very difficult, and may have to be worked out by other means.

(2) The occurrence of "scissor movement." If this condition occurs, say, in the vertical meridian, it will be noted that a double movement takes place in the fundus reflex on tilting the mirror. A portion of reflex at the top of the pupil appears to move downwards, while a portion at the bottom appears to move up. The



explanation of this condition is a little doubtful; it has been ascribed to irregular astigmatism or to partial tilting of the lens. A fairly close approximation to the refraction can be obtained by finding the strength of lens required to cause the two portions of reflex to meet in the centre of the pupil.

(3) The presence of spherical aberration in the eye. This usually causes the centre of the pupil to be more hypermetropic than the periphery, though the reverse sometimes occurs. It is guarded against by paying special attention to the central portion of the reflex and correcting this. Before describing the subjective examination, it is necessary to explain how spheres and cylinders are prescribed when a correction is required embodying these two types of lenses. The student should perform the following experiment: Take two  $+1\text{D}$  cylinders from the trial case, and place them in contact with their axes at right angles to each other, then add a  $-1\text{D}$  sphere to the combination, when it will be found to have become equivalent to a piece of plane glass. This experiment shows that two cylinders of the same sign and strength when placed with their axes at right angles to each other become equivalent to a sphere of the same strength. The converse is also true; that a sphere may be regarded as two cylinders of the same sign with their axes at right angles to each other.

Now suppose that the result of retinoscopy is

$$\begin{array}{c} +6 \\ | \\ \text{---} | \text{---} +4 \end{array}$$

We add a  $-1\text{D}$  sphere to this, and it becomes

$$\begin{array}{c} +5 \\ | \\ \text{---} | \text{---} +3 \end{array}$$

This correction can then be put up in the trial frame in any of three different ways:—

(1)  $\text{Cyl.} + 5\text{D} \rightarrow 180^\circ \text{ cyl.} + 3\text{D}$   $\downarrow 90^\circ$ , which is the most obvious.

(2) If we start again with an empty trial frame and put in a sphere  $+3\text{D}$ , the result we have achieved may be written

diagrammatically  $\begin{array}{c} +3 \\ | \\ \text{---} | \text{---} +3 \end{array}$ , which leaves  $2\text{D}$  still to be cor-

rected in the vertical meridian. This can obviously be done by



putting in a + 2D cylinder axis  $\rightarrow 180$ . The second combination would thus be sph. + 3.0 $\bar{c}$  cyl + 2.0  $\rightarrow 180$ .

(3) Start again with an empty trial frame and put in a sphere + 5 D. In this case the vertical meridian is fully corrected, while the horizontal meridian is overcorrected by 2D. This can be done away with by inserting a cylinder of - 2D axis vertical.

By a similar process the following results may be obtained :—

LENSES.	
$\begin{array}{c} \text{---} \text{---} +4 \\   \\ \text{---} \text{---} +4 \end{array}$	Cyl. 3 $\downarrow_{90}$ $\bar{c}$ cyl. 3 $\rightarrow 180$ . or Sph. + 3.
$\begin{array}{c} \text{---} \text{---} +2 \\   \\ \text{---} \text{---} -3 \end{array}$	(a) Cyl. + 1 $\downarrow_{90}$ $\bar{c}$ cyl. - 4 $\rightarrow 180$ . (b) Sph. + 1.0 $\bar{c}$ cyl. - 5.0 $\rightarrow 180$ . (c) Sph. - 4.0 $\bar{c}$ cyl. + 5.0 $\downarrow_{90}$ .
$\begin{array}{c} \text{---} \text{---} -1 \\   \\ \text{---} \text{---} -4 \end{array}$	(a) Cyl. - 2 $\downarrow_{90}$ $\bar{c}$ cyl. - 5 $\rightarrow 180$ . (b) Sph. - 2.0 $\bar{c}$ cyl. - 3.0 $\rightarrow 180$ . (c) Sph. - 5.0 $\bar{c}$ cyl. + 3.0 $\downarrow_{90}$ .

With regard to the choice of prescription in the final lens, the sphero-cylindrical form is generally used, as crossed cylinders are difficult and expensive to grind. Other things being equal, one usually chooses the form which embodies the smaller sphere. For instance, in the second example above, (b) would be preferable to (c).

SUBJECTIVE EXAMINATION.—The patient is brought out of the dark room and placed in a chair at a distance of 6 metres from the test type. The left eye is covered by an opaque disc in the trial frame, while the correction as estimated by retinoscopy is placed in front of the right eye. The patient is then directed to read the letters. It is usually advisable to try the effect of slight modifications in the lenses before deciding on the final prescription. The following is a useful routine, a change being made at any stage if it produces an improvement in vision. In order to illustrate the changes produced, take a case where the refraction

is estimated as being  
Sph. + 3.0  
Cyl. + 2.0  $\rightarrow 180$ .



- (1) Rotate the cylinder, say,  $10^\circ$  to  $15^\circ$  first to one side of the estimated axis, and then to the other, and, having found the best axis, proceed as follows :—

(2) Add a sphere  $+ 0.50$  ... Combination becomes  $\begin{array}{r} + 3.5 \\ + 2.0 \\ \hline \end{array} \rightarrow 180.$

(3) Add a sph.  $- 0.50$  . Combination becomes  $\begin{array}{r} + 2.5 \\ + 2.0 \\ \hline \end{array} \rightarrow 180.$

(4) Add a cyl.  $+ 0.50$ , with axis parallel to axis of cylinder in trial frame. Combination becomes  $\begin{array}{r} + 3.0 \\ + 2.5 \\ \hline \end{array} \rightarrow 180.$

(5) Add a cyl.  $+ 0.50$ , with axis vertical to axis of cylinder in trial frame . Combination becomes  $\begin{array}{r} + 3.5 \\ + 1.5 \\ \hline \end{array} \rightarrow 180.$

(6) Add a cyl.  $- 0.50$ , with axis parallel to axis of cylinder in trial frame . Combination becomes  $\begin{array}{r} + 3.0 \\ + 1.50 \\ \hline \end{array} \rightarrow 180.$

(7) Add a cyl.  $- 0.50$ , with axis vertical to axis of cylinder in trial frame . Combination becomes  $\begin{array}{r} + 2.50 \\ + 2.50 \\ \hline \end{array} \rightarrow 180.$

If a change is made, it is well to run through the cycle again, in order to verify the patient's statement that vision is improved by it, as contradictory statements are frequently made.

*The Final Prescription.*—(a) In cases of myopia and of myopic astigmatism it is usual to order the full correction as found under a mydriatic. Exceptions to this occur in a few cases with a high error, where the patient has not previously worn glasses, or when the patient is of presbyopic age, when a post-mydriatic test will be required for reading glasses.

(b) In cases of mixed astigmatism it is usually advisable to make a second test after the effect of the mydriatic has worn off (post-mydriatic test) to determine the best combination of lenses.

(c) In cases of hypermetropia, hypermetropic and compound hypermetropic astigmatism, a post-mydriatic test may be required. The reason for this is that the ciliary muscle regains a variable amount of tone, so that the eye will not accept such a



high sphere as it did under the mydriatic. If a second test is impossible, it usually suffices to deduct 1.0D in children under atropine, unless the glasses are for cure of squint, when only .5D is deducted. In adults under homatropine and cocaine it usually suffices to deduct .5D.

(d) In presbyopes a post-mydriatic test is advisable for reading glasses, when the procedure given under the heading of Accommodation should be carried out. If a second test is impossible, the patient's accommodation should be estimated from his age by the chart on p. 42, when the requisite reading glasses can be deduced.

(e) In anisometropia, *i.e.*, where there is a considerable difference in the refraction of the two eyes, it is often necessary to compromise so as to diminish the difference in strength between the two lenses. In children and young people, however, an effort

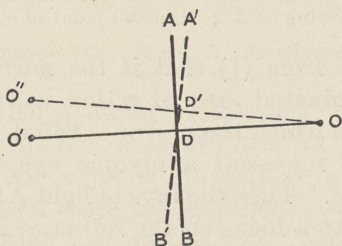


FIG. 39.—AB, mirror ; O, source of light ; O', image.

should always be made to wear a full correction in front of each eye.

THE THEORY OF RETINOSCOPY is as follows :

(1) Let AB (Fig. 39) represent a plane mirror, O a source of light, and O' its image. Join OO' and let it cut the mirror at D. Then, according to the laws of reflection of light,  $OD = O'D$ , and both are perpendicular to AB. Now imagine AB is tilted down into the position A'B', and draw O'D' perpendicular to A'B', producing it to O'' so that  $O''D' = O'D'$ . Then O'' will represent the new image of O, and it will be seen that when a plane mirror is tilted in any direction the image formed by reflection from it moves in the opposite direction.

(2) Let N (Fig. 40) represent the nodal point of an eye viewing a luminous object O, then whatever the condition of the eye, with regard to errors of refraction, a luminous area will be formed on the retina with its centre at X. Now imagine that O moves to O''. The centre of the image must still lie along the line



connecting the object and the nodal point (since by definition the rays passing through this point are not altered in direction). Therefore, the point  $X'$  where  $O''N$  produced, meets the retina, indicates the position of the centre of the new image.

Hence, in all eyes, whatever their refraction, if the object is moved, the retinal image will move in the opposite direction. If this object should be the reflection in a plane mirror of a source of

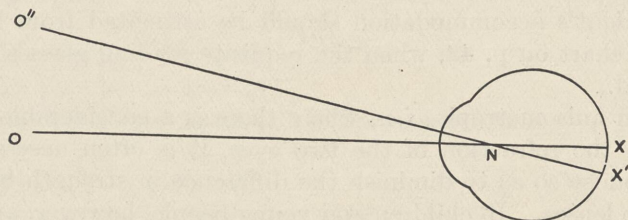


FIG. 40.—O, source of light, moved to  $O''$ ; X, illuminated area of retina moving to  $X'$ ; N, nodal point of eye.

light, then we see from (1) that if the mirror is tilted in any direction the illuminated area of retina will move in the same direction as that in which the mirror is tilted.

(3) Let Fig. 41 represent a myopic eye, and let A be the far point of this eye. Then the rays of light AD and AE emerging from A will come to a focus on the retina at X, and, conversely, if X were luminous, it would form a real image at A. Now

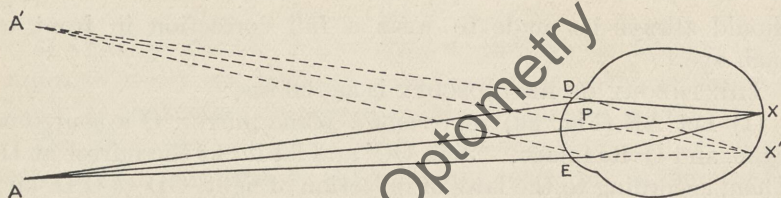


FIG. 41.—Myopic eye. X and  $X'$  illuminated areas of retina; A and  $A'$ , their images in space (see note, Fig. 30).

suppose X is moved to  $X'$ , then the same construction as before shows that its image moves to  $A'$ , i.e., in the opposite direction to the movement of X, and, therefore (from (2)), in the opposite direction to that in which the mirror is tilted. This image is visible in the performance of retinoscopy, and if it moves in the opposite direction to that in which the mirror is tilted, the eye must be myopic and the "far point" of the eye lie between the observer and the patient.



(4) Let P (Fig. 42) represent a hypermetropic eye, such that the convergent rays of light DA and EA are brought to a focus on the retina at X. Then in the same way as before, we can reverse the process and say that if X is an illuminated area of retina it will produce a virtual image behind the eye at A, and, moreover, if X moves to X' that A will move to A'. In this case the movement is in the same direction as that of the illuminated area of retina, and, therefore, in the same direction as that in which the

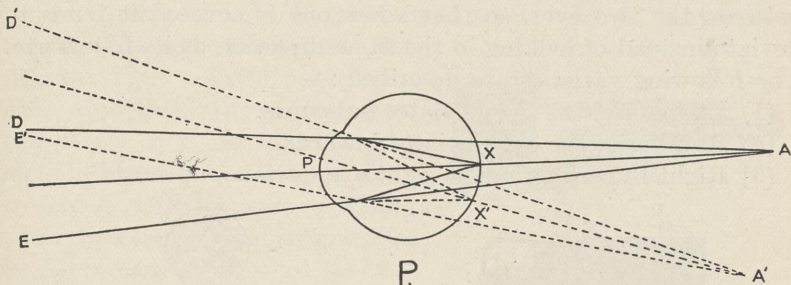


FIG. 42.—Hypermetropic eye. X and X', illuminated areas of retina ; A and A', their virtual images.

mirror is tilted. Hence, in hypermetropia, a virtual image is seen, and it moves in the same direction as that in which the mirror is tilted. It is apparent that there must be a point of neutralisation between these two extremes, where no movement can be seen on tilting the mirror. In actual practice this is found to occur when the patient's far point coincides with the anterior principal focus of the observer's eye. In this condition the observer either sees the patient's pupil full of light or devoid

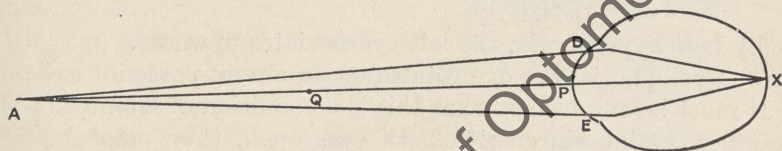


FIG. 43.—Eye with myopia of 0.50D. Q, position of observer ; A, real image of X.

of it. This means that with the observer sitting at 1 metre distance from the patient, neutralisation occurs when the patient is made 1D myopic. In myopia of less than 1D the luminous area appears to move "with" the movement of the mirror. This seems rather difficult to understand on the foregoing description, and it is best explained as follows. If in Fig. 43 the observer is seated at Q, 1 metre from the patient, and the eye is .5D myopic, A will be 1 metre behind him. Now, it is impossible to project,



to a point behind our head, light which comes into our eyes from in front. The source of light is, therefore, referred subjectively by the observer to a point behind the patient's head, so that the apparent movement becomes the same as in hypermetropia, *i.e.*, with the mirror. The various subjective tests for astigmatism and the methods for performing retinoscopy without the aid of a mydriatic will be found described in larger books.

**Heterophoria.**—This word signifies a want of muscle balance between the two eyes, so that when one is covered it tends to deviate instead of looking in the same direction as its fellow eye. The following varieties are described :—

- (1) Exophoria, the eye deviates outwards.
- (2) Esophoria, the eye deviates inwards.
- (3) Right hyperphoria, the right eye deviates upwards.

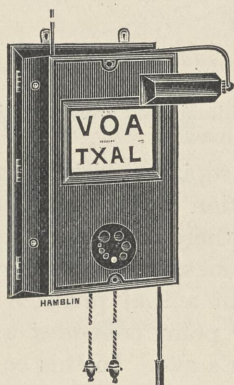


FIG. 44.—Light source for Maddox rod test placed under test type box.

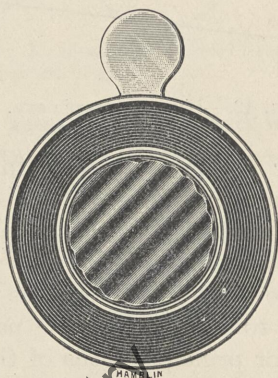


FIG. 45.—Maddox rod.

- (4) Left hyperphoria, the left eye deviates upwards.
- (5) Cyclophoria, the eye rotates on an antero-posterior axis.

It must be emphasised that this is a condition of latent, not of manifest squint, since, with both eyes open, they point in the same direction. The condition is, however, capable of causing a considerable amount of eyestrain, especially if hyperphoria be present, so that examination should always be made for its presence.

This is carried out as follows : The patient is seated at a distance of 6 metres from a source of bright light about 2 cm. in diameter. She should wear her distance correction in the trial frame, care being taken to see that the lenses are properly centred. It is advisable to cut out as much extraneous light as possible, and for this reason the source of light is usually enclosed in a box which has a diaphragm opening (*vide* Fig. 44). A Maddox rod is



now placed in front of the right eye with the rods vertical (*vide* Fig. 45). The right eye will now see a horizontal streak of red light, while the left eye sees the source of light. These two are quite dissimilar, so there is no incentive to fusion. If, then, there is right hyperphoria, the right eye will deviate upwards, and the red line will appear to pass below the light (for explanation of this, *vide* section on muscles). If there is left hyperphoria the line will be above the light. The amount of hyperphoria may be gauged by the strength of prism required in front of the left eye to bring the red streak into line with the light. Since prisms displace objects in the direction of their apices, it is obvious that the prism in front of the left eye must be placed with its apex pointing in the direction of displacement of the red streak.

The Maddox rod is now rotated so that the rods are horizontal and the right eye sees a vertical streak. If exophoria be present, the streak will be to the left of the light; if esophoria, to the right. The amount of error may again be estimated with prisms.

Cyclophoria is rare, but if present it will cause an apparent rotation of the red streak, so that with the glass rods vertical it appears to point above or below the horizontal meridian.

An instrument known as the Maddox wing test (*vide* Fig. 46) is employed for measuring the amount of heterophoria in near vision. The patient, wearing her correction, with the lenses centred for reading, is directed to look through the two slits in the eyepieces. The right eye sees a white finger pointing vertically upwards and a red arrow pointing horizontally to the left. The left eye sees two rows of figures, horizontal and vertical, printed respectively in white and red. The white number to which the finger points indicates the amount of esophoria or exophoria, and the red figure to which the arrow points, the amount of hyperphoria. The instrument is calibrated to give the result in degrees

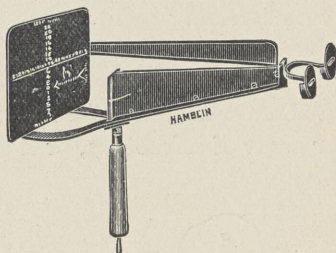


FIG. 46.—Maddox wing test. An arrangement of screens divides the visual field into two parts, so that the right eye is able to see only the white hand and the red arrow, while the left eye sees only the horizontal and vertical rows of figures. The two fields glide tangentially against each other's edges in directions opposed to the deviations of the eyes which see them.

The white hand points to a row of white figures and records any horizontal deviations.

The red arrow points to a vertical row of red figures and records any vertical deviations.



of deviation, not in prism dioptres. It is necessary, therefore, to double the reading to get the approximate strength of prism required to correct the defect.

*Correction of Heterophoria.*—(1) Hyperphoria exceeding  $2\Delta$  is usually troublesome to the patient, and may cause quite severe headaches, often in the occipital region. It generally suffices to order a prism which will correct two-thirds of the defect, splitting the effect between the two eyes if the required prism is over  $2\Delta$ . This, of course, is done by ordering the prism base up for one eye and base down for the other. If the required prism is over  $6\Delta$ , operation may be necessary to cure the defect.

(2) Esophoria and exophoria. Considerable judgment is required as to the advisability of ordering prisms in these defects. In some cases the defect may disappear after wearing a correction for error of refraction, or if present it may cause no inconvenience.

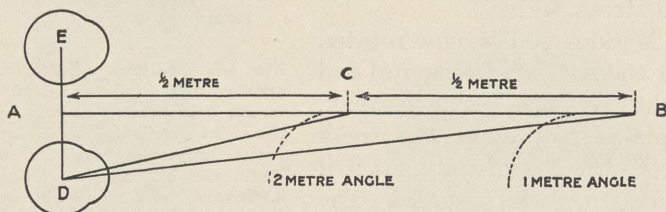


FIG. 47.—AB, mid-line between two eyes D and E; angle ACD = 2-metre angles; ABD = 1-metre angle.

Other cases are cured by means of exercises with prisms or the stereoscope (*vide* p. 234). There remain, however, a certain number of cases requiring operation or correction with prisms. The commonest types are high degrees of esophoria ( $6\Delta$  and over) and cases of convergence insufficiency. The former require prisms base out, especially for vision in the distance, the latter prisms base in, to be worn for reading.

**Convergence** is best measured in metre angles, since the principle is the same as that used in the dioptric calibration of lenses.

If the visual line of an eye is brought to bear on an object 1 metre away in the midline, the angle between the two lines (*vide* Fig. 47) is said to be 1 metre-angle, if the object is  $\frac{1}{2}$  metre away, it is said to be 2 metre-angles, and so on. The amplitude of convergence is measured by finding the nearest point at which single vision can be maintained, allowance being made for any esophoria or exophoria in distant vision. The normal amplitude



of convergence is considered to be 10·5 metre-angles, although it may be 15 or 17 metre-angles, and sometimes even more.

**The Ophthalmoscope.**—Light cannot enter or leave the eye except through the pupil. It is, therefore, obvious that we cannot see the interior of a living eye unless we look through the pupil, and that the light which is to illuminate what we are looking at must pass through the same aperture. The simplest way to accomplish this is to have a mirror with a hole in the centre. Light reflected from this mirror into the patient's eye serves to illuminate the fundus, while the observer looking through the hole in the centre secures a view of the back of the eye, because he is looking along the centre of the beam of light.

**DIRECT OPHTHALMOSCOPY**—(1) *Illumination.*—The arrange-

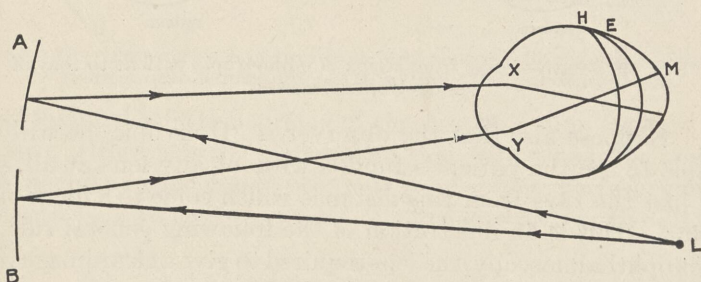


FIG. 48.—Path of rays in direct ophthalmoscopy. L, source of light; AB, mirror; H, E and M, positions of retina in hypermetropia, emmetropia and myopia.

ment of this has been described on p. 28, so we shall now discuss the path of the rays.

AB (Fig. 48) is a concave mirror of 8 cm. focal length, and L is the source of light, usually 20–30 cm. away from the mirror. XY is the pupil of the patient's eye, and M, E and H the positions of the retina in myopia, emmetropia and hypermetropia. The mirror is held as close to the patient's eye as possible, the distance separating them being about 18 mm. The rays of light from the mirror are therefore strongly convergent, as though they were going to meet at a point 10 cm. from it. Being already convergent, they are bent together further by the refracting media of the eye and cross in the vitreous, well in front of the retina. An area of fundus is thus illuminated by divergent rays, the area being greatest in myopia and least in hypermetropia.

(2) *Viewing the Fundus.*—It has already been stated that the direction of the rays of light in the eye is reversible. Therefore,



if the back of an emmetropic eye be rendered luminous it will emit parallel rays. If the observer be also emmetropic these rays will come to a focus on his retina, and he will have a clear image of the patient's fundus (Fig. 49 for path of rays). If the patient is not emmetropic he can be rendered so by glasses, and the same applies to the observer. Suppose, now, that the patient is 3D hypermetropic (*vide* Fig. 50). The rays on leaving her eye will be divergent, as though they came from a point  $O'$  33 cm. behind the

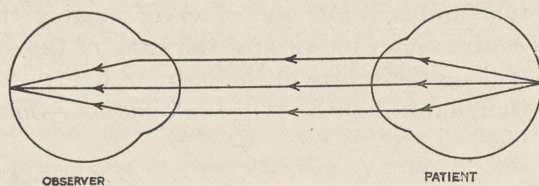


FIG. 49.—Path of rays from retina of emmetropic patient to that of emmetropic observer.

eye. Suppose also that the observer is 3D myopic, he will then be able to see the patient's fundus without any lens at all, since it is just the rays from this distance which come to a focus on his fundus. This is an illustration of the following general rule: In direct ophthalmoscopy, the lens required to give a clear image of the patient's fundus is the algebraical sum of the refraction of patient and observer. It will also be seen how it is possible to measure refraction with the ophthalmoscope. If the observer be emmetropic, and takes care not to accommodate, the highest convex

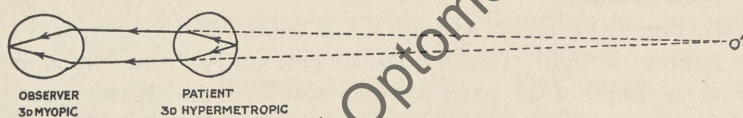


FIG. 50.— $O'$ , virtual image of patient's fundus.

or lowest concave lens with which the patient's fundus is seen clearly is a measure of her refraction, assuming that there is no astigmatism. If she is not emmetropic, the necessary addition or subtraction must be made. The ophthalmoscope should theoretically be situated at the anterior principal focus of the patient's eye. If it is further removed from the eye a higher concave or a lower convex lens is required. Astigmatism can also be measured approximately with the ophthalmoscope. Suppose, for example, we have a case requiring a  $+ 2D$  cylinder axis vertical, the edges



of the vertical retinal vessels would be clear with a  $+2$  sph., while the horizontal would be blurred, and would not come clear until the lens was decreased to 0.

Another use of the ophthalmoscope is to measure the swelling of the disc and retina in papilloedema and inflammatory conditions.

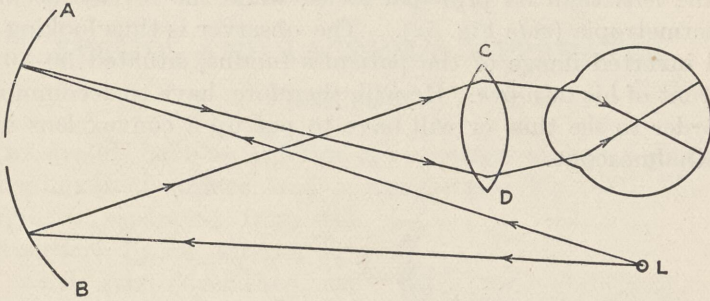


FIG. 51.—Showing path of rays from light source L illuminating fundus in indirect ophthalmoscopy; AB, mirror; CD, condensing lens.

It is found that if the surface of the disc be 1 mm. forward it can be seen with a lens 3D higher than that with which the vessels in the macular region can be seen. It is, of course, necessary in these cases to be sure that the vessel one focusses on, for the disc, runs

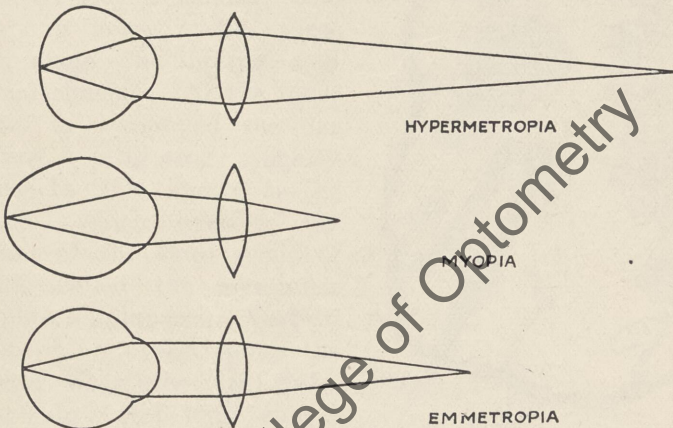


FIG. 52.—Position of image of fundus by indirect method in hypermetropia, myopia and emmetropia.

in the same meridian as that at the macula, otherwise errors may occur due to astigmatism.

**INDIRECT METHOD—(1) Illumination.**—The path of the rays is shown in Fig. 51; the mirror AB has a focal length of 25 cm.

**(2) Observation of the Fundus.**—The effect of interposing a 13D



convex lens is to bring the rays of light from the patient's eye to a focus at a point between the observer and the lens (Fig. 52). These rays are parallel in emmetropia, and will therefore meet at the principal focus of the convex lens; in myopia they are already convergent, and will therefore meet at a point nearer to the lens than its principal focus, while the reverse occurs in hypermetropia (*vide* Fig. 52). The observer is thus looking at a real inverted image of the patient's fundus, situated 30-40 cm. in front of his own eye. He will, therefore, have to accommodate in order to see this, or will have to put up a convex lens in his ophthalmoscope.



## CHAPTER III

### EYELIDS AND LACRYMAL APPARATUS

#### ANATOMY

THE eyelids have an anterior or cutaneous surface, a posterior or conjunctival surface, and a margin (see Fig. 53). The lid margin is separated from the skin surface by an anterior lip, at which the eyelashes are inserted. The lid margin and conjunctival surface are separated by a sharp posterior lip. On the lid margin, nearer to the posterior lip, open the ducts of the Meibomian glands, some twenty to forty in each lid. The upper and lower eyelids meet at an angle, the internal and external canthus. At the inner canthus is a rounded vascular structure projecting slightly between the lids, known as the caruncle, which overlies the remnant of the third eyelid of animals called the semilunar fold (*plica semilunaris*). Vertical section of an eyelid shows the following structures: (i.) Anteriorly, skin; (ii.) loose subcutaneous tissue; (iii.) muscle fibres of the orbicularis palpebrarum and, in the upper lid, of the levator palpebræ; (iv.) the tarsus or tarsal plate, continued above and below, as the palpebral fascia—laterally the tarsal plate is continued on each side as an internal and external

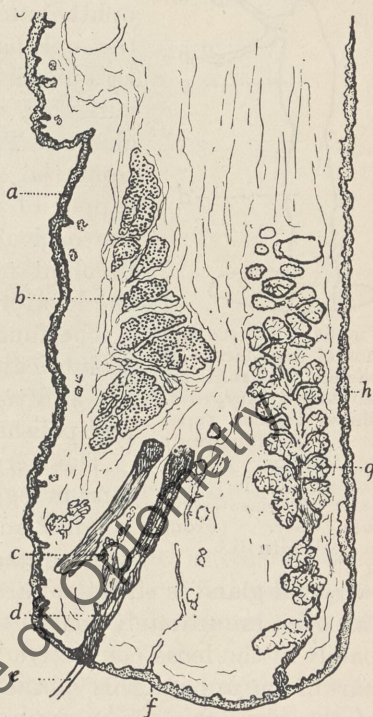


FIG. 53.—Sagittal section of upper eyelid. (a) Skin; (b) orbicularis muscle; (c) sebaceous glands of lash follicle; (d) lash follicle; (e) eyelash; (f) serous gland (Moll); (g) Meibomian gland; (h) conjunctival epithelium.



tarsal ligament ; (v.) conjunctiva. The form and the stiffness of the eyelids are produced by the dense fibrous tissue which composes the tarsal plate. Embedded in this dense fibrous tissue are the numerous Meibomian glands, which are usually visible on examination of the conjunctival surface of the lid. The hair follicles carrying the eyelashes are situated within the loose connective tissue and the muscular layers. Connected with the hair follicles are two types of gland, (i.) glands of Zeis, which are sebaceous glands ; (ii.) ciliary glands (Moll), serous glands, whose ducts open into or near the hair follicles, and are comparable with the sweat glands of the skin. The eyelids are supplied with

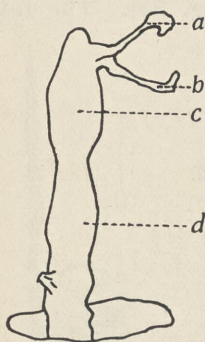


FIG. 54.—Reconstruction of naso-lacrimal passage. From an adult aged sixty years. Shows regular type.  $\times 1$ . (a) Superior ; (b) inferior canaliculus ; (c) lacrimal sac ; (d) naso-lacrimal duct. (From Whitnall.)

arterial blood, mainly from branches of the ophthalmic artery. The veins empty into the ophthalmic, temporal and facial veins. Lymphatic channels drain into the preauricular, carotid, and submaxillary lymph glands. The sensory supply of the skin is from the fifth cranial nerve. The nerve supply of the levator is from the third, of the orbicularis from the seventh, and of the involuntary Müller's muscle, connected with the levator, from the sympathetic.

The function of the eyelids is to protect, to lubricate, and to cleanse the front of the eye and to keep the corneal surface smooth and polished.

The lacrymal apparatus is composed of the lacrymal gland and of various passages which conduct any excess of lacrymal secretion from the conjunctival sac down into the nose. The

lacrymal gland is situated partly in the upper and outer part of the orbit immediately behind the upper bony orbital margin, and partly in the loose connective tissue immediately above the outer part of the upper fornix of the conjunctiva. Microscopic section of the glandular tissue shows a structure very similar to that of salivary glands, namely, secreting tubules lined with cuboidal epithelium. The ducts, variable in number, open into the outer part of the superior fornix of the conjunctiva. They are approximately ten in number. Near the inner end of both upper and lower lids, at the inner or nasal extremity of the lid margin proper, are situated the *lacrymal papillæ*. The papilla on each lid is placed at the point where the line of the lid changes direction to



form the rounded space enclosing the caruncle. On the slightly raised papilla opens a *lacrymal punctum*. The punctum is directed somewhat towards the eyeball, so that it is normally in contact with the ocular conjunctiva, in order to facilitate drainage of excess of lacrymal secretion. The punctum is the entrance into the *lacrymal canaliculus*, a minute tubule which conveys the tears into the lacrymal sac. In both upper and lower lids, the canaliculus has a very short portion, approximately at right angles to the line of the lid, and is then directed inwards under cover of the internal tarsal ligament to open on the outer wall of the lacrymal sac. The canaliculi of the upper and lower lids open close together in the lacrymal sac. The *lacrymal sac* is a thin-

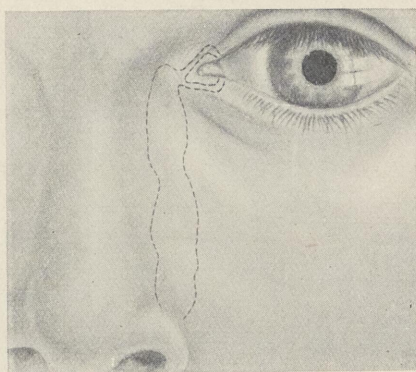


FIG. 55.—Surface marking of naso-lacrymal duct. As the patient is viewed very slightly from his left hand, the naso-lacrymal duct appears practically vertical. Normally, when seen directly from in front, it is directed slightly outwards as well as downwards.

walled structure, approximately  $\frac{1}{2}$  inch in length in the vertical direction and  $\frac{1}{4}$  inch in transverse diameter. It is continuous below with the narrower and somewhat longer naso-lacrymal duct (see Figs. 54, 55, 56).

The naso-lacrymal duct varies considerably in length, but is approximately  $\frac{3}{4}$  inch from its junction with the lacrymal sac to its opening in the inferior meatus of the nose. Both structures are thin-walled, formed of elastic and fibrous tissue, and lined by epithelium carrying columnar cells, which are sometimes ciliated. The lacrymal sac lies in a hollow formed by the lacrymal bone and the nasal process of the superior maxilla. The naso-lacrymal duct passes down in a bony canal to open on the outer wall of the inferior meatus of the nose imme-



diately below the inferior turbinate bone near its anterior end (see Fig. 56).

The lacrymal gland normally secretes just sufficient fluid to keep the cornea moist without there being any excess, this amount of secretion being evaporated from the eye. An excess of secretion is produced by irritation of the eye, as by

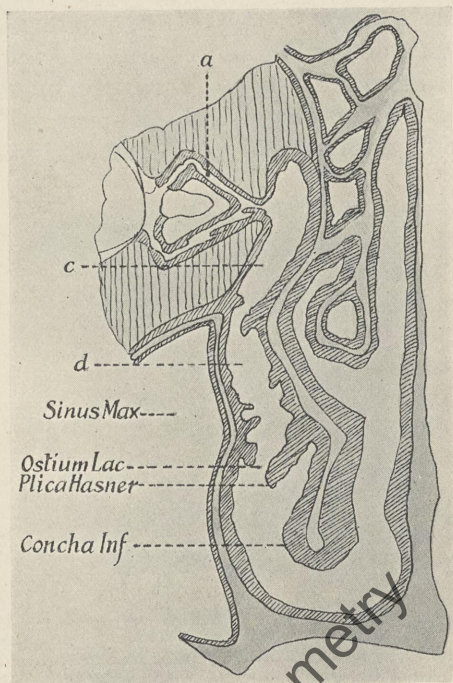


FIG. 56.—Sketch from a frontal section through the right nasal cavity viewed from in front, to show the relation of the *lacrymal passages* to the ethmoidal cells, inferior concha, and the maxillary sinus. The lining mucous membrane is shaded to emphasise its continuity. The lacrymal sac is represented as usual in an abnormal dilated condition. (After Gerard, 1907.)  $\times$  about  $1\frac{1}{2}$ . (a) Superior canaliculus; (c) lacrymal sac; (d) naso-lacrymal duct. From W. H. Witnall, "Anatomy of Human Orbit," 1921, Fig. 112.

wind or dust or smoke, and by emotional stimuli. Such excess, if moderate, is normally carried by the canaliculi into the lacrymal sac and naso-lacrymal duct, and so to the nose. Overflow, or epiphora, of the secretion is prevented, except in cases of extreme excess of secretion, by the oily lubricating fluid formed by the Meibomian glands and spread over the lid margin.



## CONGENITAL ABNORMALITIES

The only common congenital abnormality of the eyelids is *epicanthus*. This is seen frequently in children during the first few years of life. It consists in a fold of skin connecting the upper and lower lids on the nasal side, and it projects forwards and to some extent overlaps or hides the inner canthus (see Fig. 57). It may produce an appearance of convergent squint owing to its shortening to a slight extent the horizontal width of the palpebral fissure on the nasal side. It usually disappears with the forward growth of the root of the nose. If it persists, it may be treated successfully by the removal of an oval or diamond-shaped piece of skin from the root of the nose immediately between the eyes.

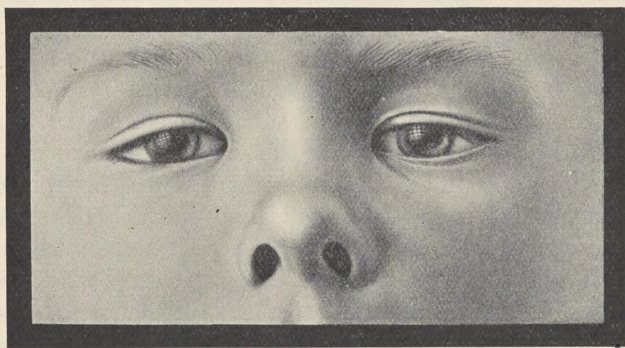


FIG. 57.—Epicanthus. There are well-marked folds of skin connecting the upper with the lower lid on the nasal side of each eye. This encroaches upon the amount of sclerotic visible and produces an apparent squint.

The long axis of this piece of skin should lie vertically. The margins of the wound are sutured with an intradermic suture reinforced by a through-and-through suture, if necessary.

*Congenital ptosis*, or drooping of one or both lids, and *congenital coloboma*, or notch of the margin of an eyelid, are rare. The diagnosis of congenital ptosis is made by a study of the history. The condition exists from birth and is not to be confounded with that which results from—

- (1) Injury to the levator palpebræ or its nerve.
- (2) Disease, such as tertiary syphilis, of the third cranial nerve or its centre of origin.
- (3) Senility.

There are three main methods of treatment by operation :—

- (1) Suture operation (see p. 251).



(2) A strip or tongue of the superior rectus, if active, may be used (see p. 253).

(3) If the superior rectus muscle is weak, a skin-strap may be prepared and implanted subcutaneously.

A congenital notch on the upper lid is less rare than that of the lower. It can be treated, in a slight case, by paring and suturing of the margins.

Microphthalmos is due to retarded and deficient development of an eye, so that it is small and usually has very defective vision or is blind.

### INJURIES OF THE EYELIDS

Comparatively trivial injuries to the eyelids are liable to produce a severe degree of *œdema* or of *ecchymosis*. Slight blows result in marked ecchymosis—the typical “black eye.” A scald or burn, a splash from a chemical irritant, such as a strong acid, is followed by a high grade of *œdema*. This is owing to the elasticity and to the laxity of the subcutaneous tissue. In every case of burns of the lids, whether thermal or chemical, the cornea and conjunctiva should be examined after the instillation of a drop of oily solution of cocaine, if this application be necessary. *Surgical emphysema* of the eyelids is recognised by the softness of the swelling and by the feeling of crepitation within the soft tissues. It is often associated with fractures which involve the walls of air sinuses connected with the nose, usually the ethmoid sinuses. If a fracture involve the orbital margin, bony crepitation may be felt on examination. Surgical emphysema is increased by efforts of straining, such as blowing the nose, owing to the escape of air under pressure from the sinuses into the loose tissues of the eyelids. Apart from the above-mentioned peculiarities, *wounds* of the eyelids are of a similar nature and require similar treatment to those which occur elsewhere, with the exception of wounds involving the lid margins. In the case of the latter, especial care is necessary in order that accurate co-adaptation of the edges of the wound be obtained. Every aseptic precaution should also be taken in order that healing by first intention may occur. Otherwise a permanent notch will result, with consequent exposure of the cornea, or epiphora in the case of scars of the lower lid margin. *œdema* and *ecchymosis* should be treated by the application of cold compresses of water or evaporating lotion. Lotions containing lead salts should only be used when there is absolute certainty that the cornea is intact. If these salts gain



access to an abrasion or other wound of the cornea, serious opacity of this structure is the result. Surgical emphysema is controlled by the application of a pressure bandage and the avoidance of straining, coughing, sneezing or blowing of the nose. Ulceration of the skin of the eyelids from burns or other cause is commonly followed by *ectropion*. Treatment for the latter usually involves the performance of a plastic operation (see p. 246).

### INFLAMMATIONS OF THE EYELIDS

- (1) *Acute*.—Erysipelas, cellulitis, anthrax (syn. malignant pustule, woolsorter's disease), boils, abscesses.
- (2) *Subacute or Chronic*.—*Lid proper*: After trauma with infection, syphilis (primary chancre or tertiary ulcer), tuberculosis (lupus vulgaris), vaccinia.  
*Lid margin*: Blepharitis.  
*Lash follicle*: Abscess (syn. sty, hordeolum).  
*Meibomian gland*: Abscess, chalazion.<sup>1</sup>
- (3) *Sequelæ*.—Scarring, trichiasis, entropion, ectropion.
- (4) *Skin Affections*.—Eczema, impetigo, herpes zoster.

(1) **Acute Inflammations**.—ERYSIPELAS affects the eyelids usually in association with the surrounding parts of the skin. It is diagnosed by the presence of typical redness and swelling with a well-demarcated indurated margin in the neighbouring skin, in conjunction with the severe constitutional symptoms of fever and malaise. It is accompanied by extreme œdema of the lids, so that the greatest difficulty is experienced in exposing the cornea.

CELLULITIS occurs in the case of severely infected wounds of the lids, or by extension from surrounding parts. It is liable to be associated with cellulitis of the orbit and with cavernous sinus thrombosis (see p. 236).

ANTHRAX usually starts by infection through a scratch or abrasion of the skin, and develops an indurated swelling in an angry, red area of intense œdema (*malignant pustule*). The skin over the centre necroses, and may slough. A history is usually obtainable of the patient's connection with the trades of hides or wool, by which the infecting organism is conveyed.

BOILS OR ABSCESES occur occasionally on the lids.

These conditions should be treated according to general surgical procedure. In all cases attempts should be made to

<sup>1</sup> Χαλαζα = hail.



open the eyelids to ensure that the cornea is intact. On recovery from the acute conditions, when loss of skin by ulceration or necrosis has taken place, precautions are sometimes required to prevent lagophthalmos by suturing the lid margins together in one or two places, and skin grafting may be required later.

(2) **Subacute or Chronic Inflammation.**—The *eyelid* is subject to varying degrees of inflammation, with or without suppuration, after the infliction of *wounds*. The degree varies with (i.) the degree of laceration or contusion; (ii.) the amount of dirt or infected material implanted; and (iii.) the virulence of the organisms. *Syphilis* occurs in the form of a primary chancre or as single or multiple gummata, which break down readily into punched-out tertiary syphilitic ulcers. Associated with a primary chancre of the lid there is usually an extreme amount of swelling and induration of the pre-auricular or submaxillary lymphatic glands. *Tuberculosis* affects the skin of the eyelid in the form of lupus vulgaris, either with or without tuberculosis of the conjunctiva (see p. 115), or, rarely, as a tuberculous ulcer. The diagnosis of these conditions is made and the treatment carried out according to the methods that are adopted for these diseases in other parts of the body.

**Blepharitis.**—Inflammation of the *lid margin*, one of the commonest affections of the eyelid, is known as *blepharitis* (see Fig. 58). It causes a sensation of irritation, burning or soreness of the lids, and occurs in two forms:—

(i.) *Dry blepharitis* (blepharitis sicca) is recognised by the presence of simple redness of the lid margin or of bran-like scales on the lid margin and around the lashes. These scales are comparable with those of seborrhœa of the scalp. Beneath them, after their removal, the lid margin is found to be reddened but free from ulceration.

(2) *Ulcerating blepharitis* is a more acute inflammation. Yellow adherent crusts of dried discharge surround the bases of the lashes. On the removal of these crusts, with forceps or a moist pad of wool or lint, after they have been softened by bathing with warm water, the skin on the lid margin is found to be red and ulcerated. This ulceration is mostly confined to the skin around the roots of the lashes. Some of the openings of the follicles may present a minute pustule, the bursting of which results in a small ulcer around its orifice and surrounding the base of the eyelash. Prolonged blepharitis results in loss and irregular growth of eyelashes and atrophy of the lid margin. The latter name is



recognised by the rounding off of the anterior and posterior borders of the lid margin. Many factors may enter into the aetiology of blepharitis. Slight degrees are caused by exposure to various forms of irritation—heat, sun, wind, dust, smoke. Short hours of sleep, much reading or other close work, especially if associated with uncorrected errors of refraction, start or aggravate the condition. Chronic conjunctivitis, especially trachoma (see p. 116) or lacrymal obstruction (see p. 84), inflame the lid margins by the resulting discharge or epiphora. The most serious cases of ulcerating blepharitis are usually seen in young children who have been debilitated by some constitutional disease. Measles, in particular, acts as a cause, owing to the presence of the conjunctivitis which is usually associated with it. Treatment consists in (1) the removal of any cause of irritation that may be found; (2) attention to the general health by the administration of tonics, fresh air and good food; vaccines are sometimes of use in intractable cases; (3) local treatment:—

- (a) Removal of scales or crusts by gentle cleansing with lint moistened in a solution of sodium bicarbonate, gr. iv ad  $\mathfrak{z}$ j (*vide* Therapeutics).
- (b) The application of mild antiseptic or astringent ointment, such as dilute ammoniated mercury ointment (1 per cent.), in the more acute stages, and yellow oxide of mercury ointment (1 or 2 per cent.) when the inflammation has to some extent subsided.

*Lash Follicle*.—A minute *abscess* which starts in the sebaceous gland of a lash follicle is known as a *stye* or *hordeolum*<sup>1</sup> (see Fig. 59). It is painful and discloses itself by the presence of more or less localised redness, swelling, and great tenderness of the lid margin. The swelling presents itself in the line of the lashes. In the centre of the swelling appears, in the course of a day or two, a small yellow spot. From this yellow centre a lash is usually seen to project. Occasionally extreme œdema of the lid results, so that the eye cannot be opened. The usual causes are general debility, constipation, and errors of refraction. Treatment includes (1) the correction of the above-mentioned errors; (2) the application of hot fomentations and hot bathing, until the yellow centre of a pointing abscess is visible. The abscess is allowed to drain by the removal of the projecting eyelash or, rarely, by incision. Rapid recovery usually follows. (3) Only in the event of repeated recurrence of styes in spite of general

<sup>1</sup> *Hordeum* = barley.



treatment, and as a last resort, an autogenous staphylococcal vaccine should be used.

*Meibomian Gland.*—An *abscess* of a Meibomian gland is relatively rare. Except for the presence of all the signs of inflammation, it bears some resemblance to the following.

A *chalazion* (syn. Meibomian cyst, tarsal cyst) is found in either lid, and is usually discovered by the presence of a swelling, small, globular and hard, beneath the skin of the lid (see Fig. 60). Its centre is usually about 3 mm. from the lid margin, well separated therefore from the line of the lashes. Occasionally two or three chalazia occur simultaneously. The swelling is usually visible in the situation indicated. If the eyelid is everted, a dusky red discoloration, sometimes with a greyish-yellow centre, is seen on the conjunctival surface, in a site which corresponds with the position of the swelling. If no treatment is adopted, the jelly-like contents may make their way through the conjunctiva and be pushed forwards between the lids as a small polypoid mass of deep red colour. Occasionally suppuration supervenes, and the painful abscess which results therefrom bursts through the conjunctiva, with relief of the pain. The swelling is due to an accumulation of granulation tissue, composed of small lymphocytes, epithelioid cells, and occasionally giant cells, within one of the Meibomian glands as the result of chronic inflammation which follows obstruction of the duct of the gland. It is incorrect, therefore, to call this swelling a cyst. As in the case of styes, general debility and errors of refraction are ætiological factors. Treatment is either medical or surgical. In the case of one or more very small chalazia, massage of the lid towards its margin, either on the eyeball or over a glass rod, and the application of yellow oxide of mercury ointment to the lid margin sometimes result in the disappearance of the swellings. If there is more than the slightest degree of discoloration of the conjunctival surface over the affected gland, surgical treatment is necessary. Whereas simple vertical (sagittal) incision of the conjunctiva into the swelling, after anæsthetisation with cocaine (see p. 242), is sufficient to drain and lead to cure of a Meibomian abscess, this treatment is quite futile in the case of a chalazion. The conjunctiva should be anæsthetised with cocaine, and also a small hole should be raised in and beneath the skin by hypodermic injection of a few drops of 1 per cent. novocaine and adrenalin (see p. 243). A vertical incision is made with a Bier's knife over the centre of the conjunctival aspect of the swelling,



and the *whole* of its contents must be removed with a small spoon or curette (see Fig. 61). The eye should be kept bandaged for the rest of the day of operation, and bathed with boracic lotion for two or three days subsequently. In the event of recurrence of chalazia, attention should be paid to the general health and to any errors of refraction that may be present. It should be



FIG. 61.—Chalazion spoon.

remembered that a transient astigmatism is sometimes produced by the local pressure of a chalazion upon the eyeball.

(3) **Sequelæ.**—The following complications may result from injuries or inflammations of the lids or conjunctiva, as also from certain other conditions enumerated below :—

- |                 |                |
|-----------------|----------------|
| (a) Trichiasis. | } See Fig. 62. |
| (b) Entropion.  |                |
| (c) Ectropion.  |                |

(a) **Trichiasis** is the inversion of one or more eyelashes. It

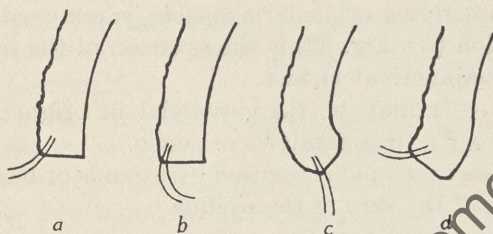


FIG. 62.—Section of upper lid, showing normal and abnormal positions.

(a) Normal ; (b) trichiasis ; (c) entropion ; (d) ectropion.

results particularly from trachoma, but also from blepharitis, and may occur by itself or with entropion.

(b) **Entropion**<sup>1</sup> is an inversion or rolling inwards of the lid margins.

**ÆTIOLOGY.**—It occurs in two forms :—

(i.) *Cicatricial* entropion affects particularly the upper lid, and results from scarring of the palpebral conjunctiva or subconjunctival tissues, especially after burns from corrosive chemicals or after trachoma (see p. 117).

(ii.) *Spastic* entropion occurs usually in the lower lid. It is

<sup>1</sup> εν = in, τρεπειν = to turn.



seen in children affected with inflammations of the eye which are accompanied by much blepharospasm (see Phlyctenular Keratitis, Interstitial Keratitis, pp. 123, 140), or in old people whose lids are lax and in whom the wearing of a bandage has, for some reason, been necessary for several days.

**SYMPTOMS.**—The inversion of the lid allows friction of the lashes against the surface of the cornea. This causes the sensation as of a foreign body in the conjunctival sac, or pain and lacrymation, and may result in ulceration of the cornea.

**TREATMENT** of trichiasis and of entropion. The displacement or inversion of a few lashes may be dealt with by repeated epilation with forceps, or by electrolysis with a weak galvanic current applied through a fine needle inserted into each lash follicle. If numerous lashes are inverted, treatment as for entropion is necessary. Entropion of the upper lid is treated by the muscle-tarsal operation (see p. 249). Spastic entropion of the lower lid should be treated by removal of the bandage, if caused thereby, and the use of a convex cardboard shield if necessary; by the application of strips of adhesive plaster to draw the loose skin of the lid downwards; or, if these methods fail, by the "skin muscle" operation, in which an oval strip of skin, with underlying orbicularis muscle, is removed (see p. 249).

(c) **Ectropion** (see Fig. 62) is the eversion of the lid with exposure of the conjunctival surface.

**ÆTIOLOGY.**—It may be (i.) cicatricial in origin; (ii.) spastic or inflammatory; (iii.) paralytic or senile.

(i.) *Cicatricial* ectropion is caused by wounds or burns—thermal or chemical—of the skin of the eyelids.

(ii.) *Spastic* or *inflammatory* ectropion occurs in acute inflammations of the eye (see above, Spastic Entropion) which are accompanied by blepharospasm, or as the result of thickening of the conjunctiva or lid margins in chronic inflammations of these parts, or from lacrymal obstruction.

(iii.) Facial nerve *paralysis* causes drooping of the lower lid from relaxation of the orbicularis muscle. It occurs in Bell's palsy and in damage to the seventh nerve from trauma—accidental or operative—or from pressure by new growths.

*Senile* ectropion is due to excessive flaccidity of the skin and muscle of the lid in age.

**SYMPTOMS.**—Epiphora from displacement of the punctum, eczema of the skin, redness of exposed conjunctiva; in extreme cases ulceration of the cornea.



**TREATMENT.**—Manipulation or massage of the affected lid, in some cases followed by suitable bandaging, relieves the slighter cases. For example, the everted lower lid of senility should be massaged in an upward direction. Chronic inflammation of the conjunctiva should be treated with astringents, such as zinc sulphate or hazeline, as described later (see p. 113). Intractable cases require operation (see p. 246, *re* Cautery of Conjunctiva, Snellen's Sutures, Skin-tarsal Operation (Kuhnt-Szymanowski), Skin Grafts).

### NEOPLASMS

- (1) *Molluscum contagiosum*.
- (2) Polypoid granuloma (from chalazion).
- (3) Cyst.
- (4) Xanthelasma.
- (5) Papilloma.
- (6) Angioma.
- (7) Plexiform neuroma.
- (8) Carcinoma: (a) Squamous-celled (syn. epithelioma);  
(b) Basal-celled (syn. rodent ulcer).
- (9) Sarcoma.

(1) ***Molluscum contagiosum*** is included under this heading, as it occurs in the form of localised nodules, although its ætiology is obscure. It is contagious.

**SYMPTOMS.**—One or more discrete, rounded, smooth nodules of pearly-white colour occur on the skin of the eyelids, as elsewhere on the body, most commonly in children. The nodules are commonly 1 to 3 mm. in diameter, frequently dimpled in the centre, and occasionally confluent. They are painless and there is no evidence of inflammation.

**PATHOLOGY.**—Microscopic sections reveal a great overgrowth of epithelium, particularly of the prickle-cell layer, whose bloated cells undergo hyaline degeneration.

**TREATMENT** is by incision into the nodules and removal of the semi-solid contents by expression.

(2) A **polypoid granuloma** occasionally presents itself between the lids as the result of the bursting of a chalazion on the conjunctival surface. A small pedunculated mass, of deep red colour, is found to be attached to the palpebral conjunctiva. This mass is composed of granulation tissue, part of which was formed beneath the conjunctiva within a Meibomian gland, the subject of a chalazion. The granuloma is removed with small scissors



while it is grasped by fixation forceps, after cocainisation of the eye.

(3) **Cysts** of the eyelid are uncommon. A cyst of one of the sweat glands, or *glands of Moll*, is situated in the line of the lashes, which it displaces on each side of it. It is readily cured by removal, with pointed scissors and fixation forceps, of the covering skin with the outer cyst wall. A *dermoid* cyst occurs in the upper lid, near its outer or inner end. It should be removed by dissecting the skin away on either side from an incision over the tumour, with care to avoid opening it. The possibility of the presence of a meningocele or an encephalocele should be borne in mind when the swelling is at the inner side.

(4) **Xanthelasma** is a flat growth of the skin of dull yellow colour, most commonly placed above the inner angle of the eyelids, and sometimes bilateral. It grows very slowly and may be removed for cosmetic reasons.

(5) **Papillomata** occur in the form of warts or cutaneous horns, of which the latter, growing from the skin near the lid margin, sometimes attain to a considerable size and project as much as an inch from their base. In the case of large growths a plastic operation may be required for closing the wound of excision.

(6) **Angeiomata** occur on the eyelid in the capillary or cavernous form. Electrolysis, excision or actual cauterisation are used in their treatment, according to their size and situation. A cavernous nævus sometimes extends into the orbit, and may prove very difficult to remove.

(7) **Plexiform neuroma** of the eyelid is very rare. It has the characteristics of this growth as when present elsewhere.

(8) **Carcinoma.**

(a) *Squamous-celled carcinoma* (syn. epithelioma) is found as a horny, a nodular, or an ulcerating growth. The first variety sometimes arises in a papilloma of the horny type (cutaneous horn). The third or ulcerating variety, with irregular, raised edge, is usually much more malignant and of more rapid growth than the others. The history of the growth is, except in the case of the horny type, invariably much shorter than that of the basal-celled carcinoma. The pre-auricular, and later the submaxillary, lymphatic glands are enlarged after the lapse of a few months.

If a case comes under treatment in an early stage of horny or nodular growth, local excision with the removal of a margin of apparently healthy skin is usually sufficient. In later stages and



in ulcerating growths a wider excision of growth and dissection of lymphatic glands is necessary.

(b) *Basal-celled carcinoma* (syn. rodent ulcer) occurs as frequently in the skin adjacent to the eye as in any part. It starts as a flat button-like projection in the skin, which slowly enlarges during the course of several years. The centre of this plaque is subject to the formation of a scab or crust, and bleeds slightly at intervals. Eventually the centre of the surface becomes ulcerated, and the raised, rolled or beaded edge extends. Early treatment is of the utmost importance, for if the growth extends into bone ultimate eradication, even by extensive bone resection, is rarely attained. On the other hand, the condition is treated with absolute success by early excision or by the application of sufficiently heavy doses of radium or X-rays. Treatment by the latter method requires supervision of the patient for a year or more afterwards, for recurrence sometimes takes place in the deeper layers of the skin at a considerable time after the attainment of an apparent cure. The ultimate fate of a case unsuccessfully treated is tragic in the extreme, owing to the extensive destruction of the skin and bones of the face and the opening up of the orbit or nasal cavities.

Sarcoma is too rare to merit detailed description.

## LACRYMAL APPARATUS

**Inflammation of the lacrymal gland** (dacryoadenitis) is rare. It produces pain, redness and swelling in the outer part of the upper lid and below the upper and outer part of the orbital margin. Only occasionally suppuration supervenes. Treatment consists in the application of hot fomentations, and incision through the skin if an abscess presents.

**Neoplasms** are very rare. A cystic dilatation of one of the ducts of the gland (dacryops) usually causes painless prominence of the outer part of the upper lid. A mixed tumour, also carcinoma and sarcoma are occasionally seen. Exenteration of the orbit, or removal of the whole contents of the cavity with the lash-bearing margins of the lids, is necessary (see Orbit, p. 241).

**Epiphora**<sup>1</sup> or overflow of tears, results from: (A) increased secretion of tears (lacrymation); (B) diminished drainage.

(A) **Lacrymation**.—The lacrymal gland secretes in health a sufficiency of tears to keep the conjunctival sac and cornea moist.

<sup>1</sup> ἐπιφθεῖν = to rush upon



This amount is evaporated from the surface of the eye, so that there is no excess available to drain into the lacrymal sac and to cause running of the nose. Lacrymation takes place as the result of stimuli acting in widely varying manner :—

(1) *Mental*, as in emotion.

(2) *Ocular*.—*External stimuli* acting upon the cornea, such as wind, smoke, dust or other foreign body ; light acting in excess upon the retina ; *internal stimuli* from various inflammations, such as phlyctenular keratitis, interstitial keratitis, iritis.

(3) *Nasal*, such as hay fever.

(B) **Diminished drainage**, due to affections of—

(1) *The lower eyelid*, namely non-development of the punctum (rare), eversion of the punctum, and ectropion as already described.

(2) *The lacrymal drainage system* :—

(a) The lower lacrymal *canaliculus* is occasionally obstructed *in the lumen* by a concretion of a fungus (*streptothrix*) or by an eyelash ; *in the wall* by stricture from wound or operation.

(b) The *naso-lacrymal duct* is obstructed rarely in infants, by epithelial *débris*, and in adults more frequently from inflammation of the lining mucous membrane. Such inflammation is catarrhal, tuberculous, or syphilitic. This obstruction is followed by the production of a mucocele, later by chronic dacryocystitis or acute dacryocystitis. Occasionally syphilitic periostitis or tumours of the upper jaw cause obstruction by external pressure on the nasal duct. The subject of lacrymal duct obstruction will be described at greater length under a separate heading.

**TREATMENT.**—Eversion of the punctum, which is often the first step in the production of ectropion, is treated by the application of astringent lotions to the conjunctiva when conjunctivitis is present, by upward massage of the skin of the lower lid, and lastly by operation. This consists in the removal of a portion of the inner or posterior wall of the canaliculus so as to throw part of the canaliculus itself into direct communication with the conjunctival sac and restore the drainage of tears.

A foreign body, be it fungoid or an eyelash, may usually be removed from the lower canaliculus by grasping with fine-pointed forceps the small portion which generally projects through the punctum.

**Lacrymal Duct Obstruction.**—**ÆTIOLOGY.**—As already stated, obstruction of the lower part of the lacrymal apparatus—the naso-lacrymal duct—occurs (1) in infants from the presence of



epithelial *débris* in the naso-lacrymal duct; (2) in children and adults most commonly from inflammation, which usually spreads into the duct from the nose. Simple catarrhal inflammation, tuberculosis in the form of lupus vulgaris, and, more rarely, congenital or tertiary syphilis are types of inflammation which cause obstruction. The closure of the passage is due to swelling of the mucous membrane from infiltration, to fibrous stricture from cicatrisation, or in rare instances to bony hypertrophy or callus.

(1) SYMPTOMS.—In *infants* the sign which draws attention to the condition is the persistent watering of one eye (epiphora), with or without the presence of mucopus in the conjunctival sac, particularly at the inner canthus. Occasionally both sides are affected. The application of gentle pressure immediately below the inner canthus causes the escape of mucus or mucopus from the lower punctum.

TREATMENT.—(a) In the majority of cases it is possible to clear the obstructing *débris* from the lacrymal duct by the application of pressure with the tip of the finger directly backwards over the inner canthus. This should be repeated on each occasion on which the eye is bathed. During the process of bathing the eye, while a pool of lotion is maintained over the inner canthus, the eyelids should be made taut by traction applied in an outward or temporal direction upon the skin at the outer canthus. This serves to close the lids, and to some extent to impede the regurgitation of fluid into the conjunctival sac. While the lids are held taut, the tip of the little finger is applied with gentle pressure over the inner canthus, so that some of the contained fluid may pass downwards from the lacrymal sac through the lacrymal duct, and so into the inferior meatus of the nose. Sometimes a single manipulation is sufficient to cure the obstruction. Usually the treatment must be continued for some weeks, three times daily.

(b) In rare instances manipulation fails to clear the passage. In such cases a lacrymal probe is passed into the sac and down through the duct into the inferior meatus of the nose (see below). Extreme care is necessary in the performance of this manœuvre in order to avoid the infliction of damage upon the lining mucous membrane of the passage. In no case should an attempt be made to syringe the sac in *infants*, owing to the delicacy of the lining membrane.

(2) *Children and Adults*.—SYMPTOMS.—Lacrymal obstruction in children and adults is usually heralded in a manner similar



to that described above. Epiphora, however, usually precedes the appearance of mucus or of mucopus by many weeks or months. After a variable period, during which epiphora has been the predominant feature, a viscid but quite clear discharge appears at intervals at the inner angle of the eye. Later the discharge is found to be semi-opaque and yellowish in colour. The first is mucus mixed with lacrymal secretion; the second is mucopus. For the method of examination for regurgitation of fluid from the lacrymal sac, see p. 8.

**DIAGNOSIS.**—Regurgitation of fluid on the application of pressure over the lacrymal sac indicates partial or complete obstruction. These are differentiated by the injection of fluid into the sac by means of a syringe and cannula (as described under the heading of Treatment, p. 88). If the fluid returns through the upper punctum during injection, two or three drops of adrenalin should be injected into the sac, and a fresh attempt at syringing should be made after two minutes' interval. The adrenalin, by causing blanching of the congested mucous membrane, may allow the passage of fluid into the nose at the second attempt.

*Partial obstruction* is indicated by (1) regurgitation on pressure; (2) passage of fluid into the nose.

*Complete obstruction* is present with (1) regurgitation; (2) no passage of fluid into the nose.

Nasal examination should be made in order to ascertain if disease of the nasal mucous membrane is present.

**COURSE AND PATHOLOGY.**—Certain sequelae are liable to occur. The sequence of events in extreme cases is as follows:—

Epiphora.

Mucus regurgitation.

Mucopus regurgitation.

Mucocele (retention of mucus and lacrymal secretion).

Chronic dacryocystitis (ulceration of mucous lining).

Acute dacryocystitis (perisaccular inflammation, usually suppurative, *i.e.* lacrymal abscess).

Serpiginous ulcer of the cornea.

With the prolonged retention of mucus and lacrymal fluid, the sac slowly dilates, and unless it is frequently emptied through the canaliculi by pressure at the inner canthus it becomes apparent as a tense, rounded swelling projecting forwards immediately below the internal tarsal ligament. This swelling, which is painless and capable of being reduced by pressure, is known as a



**mucocoele.** Micro-organisms which enter it by the canaliculi have every opportunity to multiply. The pneumococcus in particular thrives in this situation, and is of especial importance. Gradually a chronic form of inflammation of the lining mucous membrane occurs, with a variable degree of ulceration. In this stage an admixture of pus is found with the mucous contents of the sac. The condition is now one of **chronic dacryocystitis**. In this condition a fibrous tissue proliferation takes place in the wall of the sac. At the same time, owing to chronic inflammation, with swelling of the lining membrane or fibrous proliferation, the upper passages—the canaliculi and puncta—are liable to become stenosed. Increasing difficulty is then experienced in emptying the sac by pressure. If complete occlusion occurs both above and below, the gradual increase in volume of the contents of the sac and the proliferation of micro-organisms lead to an extension of inflammation through the ulcerated sac wall. An acute inflammation of the connective tissue *outside* the sac follows, and usually results in suppuration. The condition of **acute dacryocystitis** is then established (see Fig. 63, p. 108). With the development of this acute inflammation there is a rapid onset of pain, a marked increase of swelling over the situation of the lacrymal sac, redness and oedema of the overlying skin and of the lower eyelid and cheek. Some general malaise and pyrexia are often present. In the course of a few days the skin over the centre of the swelling becomes thinned, and the presence of an abscess is indicated by fluctuation. A **lacrymal abscess** often points lower down in the cheek than the situation of the mucocoele. **Serpiginous ulceration of the cornea** is included in the list of sequelæ of lacrymal obstruction, but does not arise directly therefrom. A loss of surface epithelium from any cause, such as a slight abrasion, is attended by much enhanced risks to the eye owing to the presence of a culture of pneumococci in the stagnating lacrymal sac. Infection of a corneal abrasion by pneumococci is very liable to result in serpiginous ulcer (syn. hypopyon ulcer, ulcer serpens; see p. 132). In this form of ulcer there is always a grave danger of the ultimate loss of the eye. Hence there is a sword of Damocles overhanging every case of chronic dacryocystitis.)

**TREATMENT.**—*Epiphora* should be treated by the removal, as far as possible, of any cause that can be found, according to the classification given (see pp. 84, 85).

*Partial obstruction of the lacrymal duct* is treated by repeated weekly syringing of the lacrymal sac with boric acid lotion or



normal saline solution. Attempts to dilate the duct by means of a lacrymal probe (see Fig. 64) are almost invariably useless, except in the case of obstruction in the infant. In the latter, as already stated, the use of a probe is indicated when other measures fail, in order to clear away epithelial *débris* from the lower end of the duct.

*Complete obstruction of the lacrymal duct*, with the formation of a mucocele or chronic dacryocystitis, is relieved by removal of the whole of the lacrymal sac by operation (see p. 243). It is relieved in the sense that the source of the unpleasant and dangerous regurgitation of mucus or mucopus is removed. It does not restore the normal drainage mechanism of the tears. Since, however, in the absence of irritation in any form the lacrymal secretion is just sufficient for the health of the eye, there is usually no epiphora after this operation has been performed. The normal lacrymal secretion is evaporated from the eye, and the absence of a drainage system is only noticeable in certain circumstances. In the presence of conjunctival or ocular inflam-



FIG. 64.—Nettleship's canaliculus dilator.

mation, or of cold air, wind or dust, an excess of lacrymal secretion occurs, and in these conditions epiphora is liable to be present.

An alternative operation is known as West's operation. It consists in the formation of a fistula between the lacrymal sac and the nasal cavity, by the removal of part of the lacrymal bone and of the inner wall of the sac by the nasal route.

*Acute dacryocystitis* is treated after the manner of any superficial acute inflammation. The application of moist heat by means of repeated hot bathing and the use of hot fomentations relieves pain, and usually hastens the formation of a localised abscess. Occasionally the acute inflammation subsides without suppuration. In such cases the lacrymal sac should be excised soon after the subsidence of all signs of the acute condition, in order that a recurrence may be forestalled. When a definite abscess is present drainage should be provided by free incision. A lacrymal fistula frequently results, and must be excised with the unobliterated remains of the sac at a later date.

*Technique* of (1) passing a lacrymal probe ; (2) syringing the lacrymal sac :—

- (1) The eye is cocainised. The lower punctum is exposed by



retracting the lower lid. In this procedure each instrument must be held between finger and thumb as though it were lighter than a feather. The point of the dilator (see Fig. 64) is carefully introduced into the punctum at right angles to the lid margin. When the pointed end is within the punctum the instrument is turned through 90 degrees so as to point towards the inner canthus. Gentle pressure, applied *without rotation* of the instrument, in this direction for several seconds dilates the punctum sufficiently to allow the introduction of a probe of medium calibre. The probe is introduced in a similar manner, at first at right angles to the lid margin, and then in the direction of the inner canthus. When it has passed for several millimetres towards the nose it is felt to come in contact with a firm, resistant wall—the lacrymal bone, covered by periosteum, and the thin wall of the sac. If, as is required rarely except in the case of infants, the probe is to be passed down into the lacrymal sac, it is again turned approximately through 90 degrees after having been withdrawn from contact with the lacrymal bone. The direction in which the instrument should be passed downwards is given by two points. The upper point is immediately to the nasal side of the inner canthus. The lower point is on the lateral junction of the ala nasi and cheek (see Fig. 55). In its downward passage the probe should pass slightly backwards. In the case of obstruction in an infant, comparatively gentle pressure of the probe in the direction indicated will enable the extremity of the instrument to pass through the length of the nasal duct and into the anterior part of the inferior meatus of the nose.

(2) In order to syringe the lacrymal sac the preliminary steps are the same as described above, as far as the dilatation of the punctum. For the lacrymal syringe an ordinary 1 or 2 c.c. "Record" syringe is quite satisfactory. This is armed with a lacrymal cannula (see Fig. 65) and is filled with boracic lotion or saline. The end of the cannula is introduced into the punctum immediately after dilatation, and into the canaliculus, in exactly the same manner as for the probe. The cannula is so arranged that the curved end shall be directed slightly downwards into

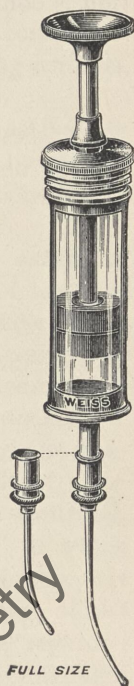


FIG. 65.—  
Lacrymal  
syringe and  
silver can-  
nula.



the sac when the instrument is in place. When it is felt that the cannula touches the lacrymal bone, the syringe is withdrawn sufficiently to leave the cannula end free in the cavity of the lacrymal sac. The patient's head is now tilted forwards slightly. Moderate pressure applied to the piston of the syringe is sufficient to inject the fluid into the sac. If the lacrymal duct is patent, fluid passes into the nose and out through the nostril. If obstruction is complete, fluid returns through the upper canaliculus.



## CHAPTER IV

### INJURIES OF THE EYEBALL

(A) **Non-penetrating injuries** of the type known as *concussion injuries*, which are often also associated with penetrating wounds, affect the various structures of the eye as follows :—

**Conjunctiva.**—*Wounds and lacerations* of the conjunctiva are not common, owing to the reflex protection of the eye by closure of the lids. The wounded conjunctiva is easy to repair owing to its laxity, and usually heals readily.

(1) *Subconjunctival hæmorrhage* occurs often as an extensive “beefy” red or dark-red discoloration of the white of the eye, owing to extravasation of blood in the loose connective tissue beneath the conjunctiva. Although it is one of the slightest injuries to which the eye is subject, yet it is one that causes the greatest amount of alarm to the patient, owing to its appearance.

It arises as the result of a small punctured wound of the conjunctiva, in which a venule is damaged; as the result of over-exertion, in which a normal or an unhealthy vessel is ruptured, or as the result of a “Saturday night’s indiscretion,” in which the conjunctival vessels have become intensely engorged. It occurs, not altogether infrequently, in healthy young adults spontaneously, and is not, therefore, in every case to be regarded as due to the intake of excessive alcohol. Such hæmorrhages need no more treatment than bruises of the skin and are absorbed in the course of one or two weeks (see Fig 80, Plate IV., p. 116).

*Burns* of the conjunctiva occur as the result of the splashing of strong acids or the entry of caustic alkalis into the eye, or in severe burns of the face from fire. After the separation of the resulting slough, there is great liability to adhesion of the eyelid to the eyeball—symblepharon. This can to some extent be prevented by the daily passage of a glass rod covered with sterile vaseline between the eyelid and the eyeball, so as to break down any adhesions that may form. Gradually the raw area will become covered with epithelium from its edges.

The cornea is affected in a similar manner and at the same time as the conjunctiva. The degree of impairment of vision that



follows depends upon the site and severity of the corneal lesion. In the treatment of burns by corrosives, early removal of the irritant, as by extraction of fragments of lime with forceps, and gentle lavage with warm water or saline in all cases, is necessary. To neutralise traces of lime left on the cornea, lavage with a 10 per cent. solution of neutral ammonium tartrate should be applied.

A guarded prognosis should be given in all cases of corrosive burns. Scarring and disfigurement of the eyelids may follow, varying in degree with the severity of the injury. Plastic operations are sometimes necessary to restore mobility or protective covering to the eye.

(2) **The cornea** is most commonly affected by the introduction into its superficial layers, usually the epithelium only, of minute *foreign bodies*, such as tiny fragments from an emery-wheel, minute spicules of steel or iron in workshops. By various methods it may suffer an *abrasion* of the epithelium, of which not the least frequent is that produced by an infant's finger nail when indulging in a game with its mother. Less common than these are lacerations or wounds of varying depths in the substantia propria by a variety of instruments.

The means by which the most minute lesions are detected is by noticing the change in the reflexion of a bright lamp seen on the surface of the cornea, every part of the surface being scrutinised carefully while the patient is instructed to move the eye in following the movements of a finger in every direction.

In the case of minute abrasions without the presence of any foreign body on the surface, the instillation of a drop of 2 per cent. fluorescein into the conjunctival sac often displays an otherwise unnoticed lesion by the brilliancy of the green colour which the abraded area takes up.

The cornea is often irritated, or is the subject of acute pain, owing to the presence of a fragment of grit on the conjunctiva of the upper lid. This is due to the repeated scratching of the sensitive cornea in blinking. The removal of the foreign body is easily accomplished by means of a wisp of cotton wool after eversion of the upper lid (see p. 5).

A small foreign body may be removed from the surface of the cornea after cocainisation, with a twisted wisp of moistened cotton wool or an iris reposer (see Fig. 173), if it is not actually embedded. The foreign body is made to slide off the cornea. If, however, it is embedded in the epithelium or the substantia



propria, more drastic measures are required. Great care should be taken to avoid injury to more corneal epithelium than is absolutely necessary. For this reason, a good light, an assistant to hold a condensing lens, and a corneal magnifier should be employed. The modern binocular corneal microscope very greatly facilitates the removal of foreign bodies with a minimum of injury to the epithelium. An eye spud with rounded end is used most frequently. A sharp Bowman's needle, however, is very useful for digging out a deep foreign body, and for removing the ring of rust which usually remains beneath a particle of iron or steel.

After a foreign body has been removed from the cornea, the affected eye should receive a drop of 1 per cent. atropine sulphate, and be bandaged for twenty-four hours. Occasionally such an eye is subject for months afterwards to attacks of soreness and

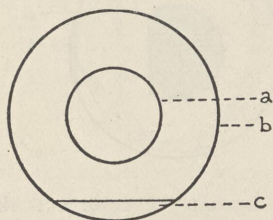


FIG. 66 shows the position of a hyphæma, or collection of blood, in the anterior chamber in the ordinary position. (a) Pupil margin; (b) corneal margin; (c) hyphæma.

lacrymation. This is due to a small local elevation of the epithelium at the site of the injury, and is known as *recurrent abrasion of the cornea*.

In addition to injury by chemical action, abrasion, or the introduction of foreign bodies, the cornea suffers damage as the result of exposure. The commonest causes of such exposure are paralysis of the seventh cranial nerve and loss of substance of the upper eyelid by injury or ulceration.

(3) **The iris** is subject to a great variety of lesions, the commoner of which are—

- (a) Small radial lacerations of the pupil margin;
- (b) *Iridodialysis*, from which
- (c) Blood in the anterior chamber or *hyphæma* results (see Fig. 66).

Fig. 66 illustrates the appearance seen by examination of the eye with oblique or focal illumination. The light is focussed on to



the eye by means of a focussing lens from one side, approximately at an angle of 45 degrees from the line of observation. The iris is then brightly illuminated, and the pupil and any holes in the iris are seen black owing to the absence of light from within the eye. Iridodialysis is the separation of the iris from its root by tearing at its thinnest portion. The result is that the iris, in the region affected, is displaced mesially from the periphery, and the pupil margin in this region forms a straight line so as to produce a D-shaped pupil (see Fig. 67). If the iridodialysis is sufficiently large, a small black strip will be seen at the extreme periphery of the anterior chamber, representing the gap between the root of the iris and its normal attachment to the ciliary body.

Fig. 67 also illustrates the appearance of such lesions, as

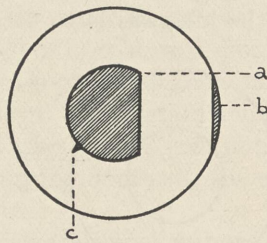


FIG. 67.—IRIS. RADIAL RUPTURE AND IRIDODIALYSIS.

The appearance on examination of the eye by oblique or focal illumination in the case of a small radial rupture of the pupil margin, and of an iridodialysis, in which appear a D-shaped pupil and a black band at the root of the iris. (a) Margin of D-shaped pupil; (b) tear at root of iris; (c) radial rupture of pupil margin. (These two conditions, of course, do not necessarily occur together. The small radial rupture may occur alone or an iridodialysis alone.)

examined by reflected light by means of a concave mirror which projects light into the eye—the light being reflected from the choroid so that the pupil and any ruptures of the iris, such as the gap at the root of the iris, appear red owing to the normal red reflex.

In *cyclodialysis*, or separation of the ciliary body from its attachment, the iris and ciliary body are displaced backwards and outwards on the side affected, so that the pupil is drawn in the same direction. The pupil in such a case resembles that shown in Fig. 71.

Fig. 66 shows the typical situation of a hyphæma. The blood, owing to the force of gravity, falls to the lower limit of the anterior chamber and displays a straight line at its upper margin. If the patient is made to lie down on one side, the blood will slowly



change its position and fall in a similar manner to the most dependent part of the anterior chamber.

(4) **Lens.**—(a) *Opacities* with a beautiful stellate appearance sometimes develop superficially in the *lens* near the anterior or posterior surface, as the result of a concussion injury. The posterior opacities are sometimes, to some extent, transient, and may disappear entirely in the course of a few weeks.

(b) The lens suffers *dislocation*, partial as in subluxation, or complete. In the latter it is displaced into the vitreous, or into the anterior chamber so as to occupy almost the whole of this cavity and to push the iris backwards (Fig. 68); or, thirdly, through a rupture of the corneo-scleral junction into a position beneath the conjunctiva—a subconjunctival dislocation. The

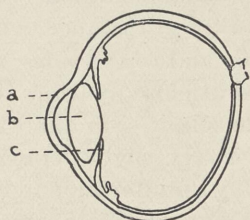


FIG. 68.—LENS DISLOCATED INTO ANTERIOR CHAMBER.

Section of an eye in which the lens has been dislocated into the anterior chamber. (a) Cornea; (b) lens; (c) iris.

rupture of the eye is, in such cases, in the usual situation near the corneo-scleral junction, and upwards and inwards.

A subconjunctival dislocation bears some resemblance to a cyst of the conjunctiva or an implantation cyst on the surface of the sclera. A lens dislocated into the anterior chamber, after it has become to some extent opaque, as usually occurs, is reminiscent of the appearance of an acid drop.

(5) **Vitreous.**—Just as hæmorrhage may take place into the anterior chamber, as the result of a concussion injury, so hæmorrhage may take place into the *vitreous* to a very variable extent, so as to cause the appearance of slight opacities of the nature of a black cloud tending to gravitate into the lower part of the vitreous, or as small black streaks of opacity. These are visible on examination of the eye with reflected light from a mirror at 1 or 2 feet distance, just as by direct ophthalmoscopy and the employment of a +4.0 to +8.0 dioptré lens in the ophthalmoscope held close to the eye. On examination by either method, slight movements of the patient's eye cause a movement in the



black opacities, which are seen to float across the red reflex from the fundus. This slow floating movement is very distinctive of the presence of a floating opacity in the vitreous. In more extreme cases of hæmorrhage the whole of the red reflex may be completely abolished, and this absence of the red reflex, after a blow, should always raise the suspicion of an extensive hæmorrhage into the vitreous.

(6) **Retina.**—*Detachment of the retina* is a serious occurrence, and may result after a concussion injury owing to the presence of hæmorrhage between the retina and the choroid, or to a serous effusion in this situation. The possibility of this injury should always be borne in mind after severe blows as by a fist. There may be no sign of detachment within a short time of the injury, but careful examination should be made both by reflected light from a mirror held at 1 or 2 feet distance, while the eye is directed upwards, and downwards, and to the sides, and also by the direct ophthalmoscopic method at close quarters with the use of + 4·0, + 6·0, or + 8·0 dioptré lens in it. In almost every case of detachment, that is more than a very slight detachment, some suspicion of the condition is raised by the alteration in the brilliancy or colour of the red reflex, as seen by examination at a distance. Particularly careful examination should be made of the lower part of the fundus, for, owing to the action of gravity, fluid, whether it be blood or serous effusion, tends to detach the retina particularly in the lower quadrant. A localised contraction of the field of vision can usually be detected in an early stage of retinal detachment.

(7) **Choroid.**—*Rupture of the choroid* is rarely seen in the early stages—that is before several days have elapsed from the time of occurrence of the injury. The reason for this is that an injury of sufficient severity to cause rupture of the choroid causes an extensive hæmorrhage into the vitreous or else a marked œdema and cloudiness of the retina sufficient to mask the other condition. After the elapse of a few days, a rupture of the choroid may be seen as one or more crescentic or sickle-shaped white marks or streaks in the fundus. If the rupture or tear of the choroid is complete through all its layers, the rupture appears as a dead white streak, often with dark pigment at its margin. If the rupture is not complete, it is usually the capillary layer of the choroid that is torn and some of the larger choroidal vessels may be seen through the tear on the white ground of the sclerotic, which is seen through. The situation of these tears is generally



in the neighbourhood of the optic disc or the macula, and they are arranged concentrically with these structures (Fig. 69).

(8) The **optic nerve** is sometimes affected with the development of *hæmorrhage in the sheath* of the nerve; the result of the presence of a collection of blood within the sheath of the nerve is pressure upon the nerve. This, in early stages, may cause an appearance of papilloedema which is succeeded, in the course of a few weeks, by the development of atrophy of the nerve and the appearance of

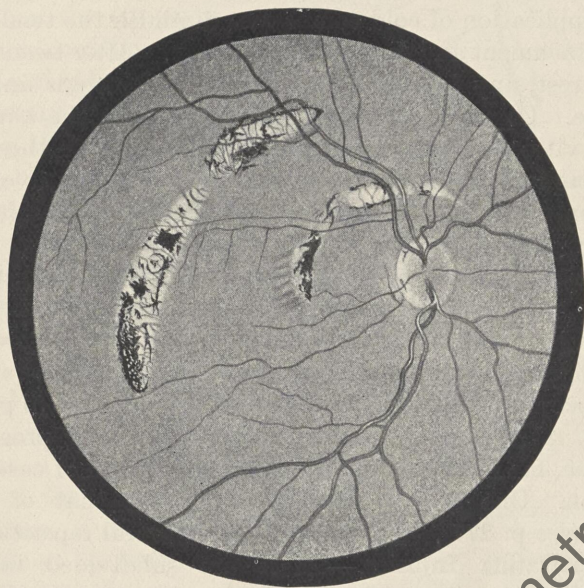


FIG. 69.—RUPTURE OF CHOROID.

Drawings of the fundus of an eye, in which the choroid had been ruptured. The retinal vessels are drawn in outline. Above and to the temporal side of the optic disc (right eye) are several concentrically arranged areas whose outlines are marked strongly in the drawing. On these patches is an excess of pigmentation. The patches themselves, in examination with an ophthalmoscope, are dead white with a few red streaks passing across them, indicating remaining larger choroidal vessels. The white and pigmented patches are surrounded by normal red fundus. *Drawing by Hamblin.*

optic atrophy, recognised by the pallor of the optic disc. It should be remembered that papilloedema is a condition of swelling of the tissues forming the optic disc, with pouting of the edges of the disc or prominence of the whole of the nerve-head, sometimes associated with small radial streaks of hæmorrhage on the swollen nerve-head. Although, clinically, it may resemble very closely papillitis, yet it is distinct from it pathologically, in that there is



œdema, without any actual cell-infiltration the result of inflammation. Severe injuries or wounds may sever the optic nerve, resulting in optic atrophy.

**Treatment of concussion injuries** of the eye consists essentially in rest, which should be enforced as early as possible. Particularly when either intraocular hæmorrhage or detachment of the retina have occurred, further damage is likely to ensue in the absence of rest. The ciliary muscle is put at rest by atropine drops, and the eyeball is protected by bandaging. Rest in the reclining position and the application of cold compresses diminish the tendency for retinal detachment and further hæmorrhage. After twenty-four's complete rest, any further intraocular hæmorrhage is unlikely to take place. Complete absorption of blood from the aqueous or from the vitreous humour often follows, even when these media are so opaque from hæmorrhage that no red reflex is obtained. Absorption may continue over several weeks, and useful vision result in what may at first appear a hopeless case.

When the diagnosis of retinal detachment is established, the only hope of recovery of vision is by complete rest in bed in the supine position for a period of from four to six weeks. If no definite signs of improvement appear within ten days, during which subconjunctival injections of hypertonic saline (5 per cent.) are given, resort should be had to operation. The prognosis is, in any case, far from good, but a small proportion of cases regain fair vision. One of the best procedures is that of cautery puncture (see p. 277). This may require several repetitions.

(B) **Penetrating Injuries.**—These are subdivided into: (1) Corneal wounds; (2) corneo-scleral wounds; (3) scleral wounds.

In wounds in any of these situations, ordinary examination of the eye by focal or oblique illumination and by the use of the ophthalmoscope may fail to decide whether the wound is simply one of penetration or whether it is one of penetration with retention of a foreign body inside the eye. In order to elucidate this point, the assistance of a radiologist is required.

(1) (a) *Simple perforating wounds of the cornea* without involvement of the deeper structures of the eye are detected, first, as in the case of foreign bodies on the surface of the cornea or abrasions of the cornea, by observing the appearance of the reflexion, from the surface of the cornea, of the source of illumination. If a window is the source of illumination, the reflexion of the window in the cornea is observed while the patient is made to move his eye in all directions. Careful examination in this



manner will disclose usually even the smallest wound. If doubt exists, a drop of sterile 2 per cent. fluorescein should be placed in the conjunctiva. A brilliant stain of green will be present at the site of the wound. Secondly, the anterior chamber is usually shallow owing to the loss of aqueous humour. A simple corneal wound is very much easier to treat and of very much less severe prognosis than the following two conditions.

(b) When the cornea is perforated, a frequent complication, particularly if the wound is towards the periphery, is the *prolapse* or entanglement of a portion of the *iris* in the wound. The iris may be merely caught up to the posterior or deep lips of the wound, or it may protrude through the cornea and project as a dark, rounded mass above the surface of the cornea. The diagnosis of this condition is of extreme importance and urgency; successful treatment of the condition depends essentially upon early diagnosis, for if the iris is left within the lips of the wound for more than a few hours, it becomes very much more difficult to free it and to save the eye from infection.

(c) Deeper wounds of the cornea, by instruments which pass further into the cavity of the eye, produce *injury of the lens* (*traumatic cataract*). A tear of the capsule of the lens allows aqueous to enter into the lens and cause it to become opaque. In some cases the whole lens becomes densely opaque and vision reduced almost to nil. In other cases if the wound of the lens capsule is extensive, the lens matter is slowly absorbed by the action of the aqueous, and the pupil eventually becomes clear and black for some of its extent.

(2) More serious still than group 1, as described above, are wounds at the *corneo-scleral junction* or immediately behind it, over

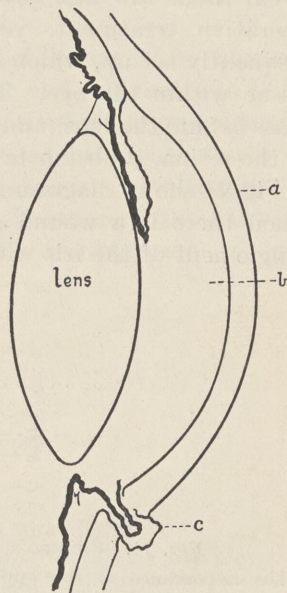


FIG. 70.—SECTION. PROLAPSE OF IRIS THROUGH CORNEO-SCLERAL JUNCTION.

Outline drawing of microscopic section of penetrating wound close to the angle of the anterior chamber in which the iris has prolapsed. (a) Anterior surface of the cornea; (b) anterior chamber; (c) knuckle of prolapsed iris, producing the prominence, as indicated in Fig. 71.



the *ciliary body*. Wounds in this situation are inevitably associated with some degree of prolapse of uveal tissue. Some of the ciliary body or of the root of the iris or both are prolapsed into the wound, with the common result of infection of the eye from without. Even if such a wound and a small amount of entangled uveal tissue are well covered with conjunctiva, as the result of operative treatment, yet a mild degree of inflammation is frequently set up, which leads to the formation of extensive scar tissue within the eye. This scar tissue may form an extensive mass behind the lens, and, even if it does not lead to detachment of the retina, it obstructs the entry of light into the eye.

Fig. 71 shows diagrammatically the appearance frequently seen when there is a wound at the corneo-scleral junction with entanglement of the iris with or without ciliary body in the lips of

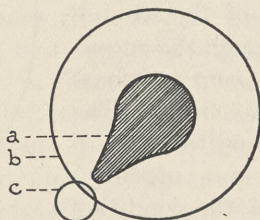


FIG. 71.—CORNEO-SCLERAL WOUND WITH IRIS PROLAPSED.

The appearance of the pupil in a case of penetrating wound at, or near, the corneo-scleral junction in which the iris has prolapsed. (a) Pupil drawn towards the wound; (b) corneal margin; (c) the circle represents the situation of a bulge or prominence at the site of prolapse, in examination by daylight or focal illumination. The prominence is usually black in colour (uveal pigment).

the wound. An extremely important sign, to assist in the diagnosis of the condition, is the extension of the pupil towards the periphery in the direction of the wound, as shown in the figure.

(3) Wounds of the *sclera* are not so serious as corneo-scleral wounds from the point of view of prolapse of uveal tissue, but the consequences of wounds in this situation are *prolapse of vitreous*, *extensive hæmorrhage into the vitreous* and, at a later date, the *formation of fibrous tissue* within the vitreous, which commonly causes *detachment of the retina* and thereby, too, loss of sight.

(C) **Rupture of the coats of the eye**, including the sclerotic, is usually produced by a blow upon the eye from some large object, such as the fist. Various other objects besides the human fist have produced this injury, such as a golf ball, a racket ball, or



even a turnip. The commonest situation for the rupture is upwards and inwards, close to the corneo-scleral junction; the rupture occurs as a crescentic depression immediately posterior to the corneo-scleral junction (Fig. 72); not infrequently there is prolapse of part of the ciliary body. This discloses itself as a deeply pigmented mass projecting slightly above the surface of the globe.

Consideration of the subject of injuries of the eye is not complete without reference to inflammations of the eye. Included in these are corneal ulcer, as the result of an abrasion or the presence of a foreign body on the surface of the cornea; panophthalmitis or suppuration within the eye and affecting its coats, resulting in the formation of pus within the aqueous chamber or the vitreous cavity, or both. A possible but rare complication of any

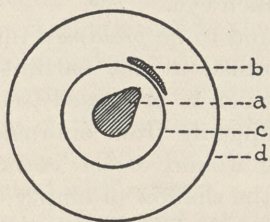


FIG. 72.—SCLERAL RUPTURE, RIGHT EYE.

Shows the situation of the most common type of rupture (right eye) as examined in daylight or by focal illumination. (a) Pupil drawn upwards and inwards towards the rupture; (b) site and common extent of the rupture, just posterior to the corneo-scleral junction; (c) corneal margin; (d) equator of the eye.

penetrating wound is that of sympathetic ophthalmia. Briefly, this is a plastic inflammation of uvea of the uninjured eye, which occurs at a variable time from about two weeks onwards after the injury of the first eye. Although it is of rare occurrence it is of extreme importance, for its development usually results in complete blindness of both eyes (see p. 163).

**Treatment of Perforating Injuries.**—*Simple non-lacerated wounds*, when not severely infected, heal rapidly and with only a moderate amount of inflammatory reaction under treatment with atropine, bathing with boric acid lotion and the application of a light pad and bandage. A *lacerated wound* of the cornea with a degree of infection moderate in severity, but in which, nevertheless, a hypopyon is produced, is sometimes treated satisfactorily by lavage of the anterior chamber. A solution of hydrogen peroxide of from three to five volume strength is used (see Fig. 177, and p. 265). It is introduced by means of a silver cannula, a rubber



tube, and an undine. Excess of peroxide solution is washed out with normal saline. The corneal wound is then covered by suturing undermined conjunctiva. In order that this may be accomplished, the conjunctiva is incised close to the cornea for a considerable portion of the circumference of the latter. The conjunctiva is freely undermined with scissors and then drawn together by a purse-string catgut suture. This procedure is capable of covering the cornea to the desired extent. This treatment is followed by oral administration of urotropine or hexamethylene tetramine, grs. x. t.d.s., with acid sod. phosph. gr. xx.

In cases of *severe infection*, the cornea may become intensely infiltrated, and even slough, pus may form in the anterior chamber and if the eye is not excised, a long and painful illness may result only in a blind, shrunken eye.

When the *iris* is found to be *prolapsed* into a wound, an operation should be performed at the earliest possible moment to remove the portion which is prolapsed (see p. 272) and free the edges of the iris completely from entanglement in the wound. A case of perforating wound of the cornea is detected by the break in the surface, the shallow or empty anterior chamber, and the flabby state of the eye from reduced tension. Every effort should be made to have such an eye examined by an expert without delay if there is the least doubt as to the entanglement or prolapse of the iris. If actual prolapse of the iris through a peripheral corneal wound has not occurred, but merely incarceration or entanglement within the deep lips of the wound, the use of eserine is indicated. Its administration half-hourly, in the form of  $\frac{1}{2}$  per cent. drops of the sulphate, will sometimes, by constriction of the pupil, free the iris and draw it completely into the anterior chamber, if applied within a few hours of the time of the injury. Conversely, the use of atropine drops may be effective in a similar condition in which the pupil margin is involved. If, owing to delay, it is found that the corneal wound remains gaping, after abscission of the prolapsed portion of the iris, closure of the anterior chamber may be obtained by covering the wound with undermined conjunctiva (see above).

Apart from the one exception above-mentioned, atropine should invariably be used in the treatment of corneal wounds, in order to prevent the formation of posterior synechiæ. It should, however, be used as a  $\frac{1}{4}$  per cent. solution in patients of over forty years of age, owing to the risk of its exciting the development of glaucoma.



*Traumatic cataract* of such degree that the vision is reduced to perception of hand movements is treated in children and young adults by needling (see p. 270), provided that the field of vision is not contracted to light. (For light projection, see p. 14.) Definite contraction of the field suggests the presence of detachment of the retina and contra-indicates operation. Absorption of the opaque lens by this means restores a full field of vision for large objects, and renders the eye of some value. Although with a suitable lens the eye may then by itself have normal vision, it is incapable of restoring stereoscopic vision. A lens, therefore, is not prescribed.

*Corneo-scleral wounds*, with prolapse of the ciliary body, must be covered over with conjunctiva, so as to protect the uveal tissue from infection and prevent the onset of sympathetic ophthalmia. The conjunctiva is freed from its attachment at the corneo-scleral junction adjacent to the wound and widely on either side. It is freely undermined, and then sutured together in such a way as to cover the wound completely and to overlap a considerable portion of the cornea. Before the conjunctiva is drawn together over the wound, any prominent tags of prolapsed ciliary body are removed with scissors.

*Scleral wounds* cannot be sutured satisfactorily, and are closed in a manner similar to that for corneo-scleral wounds. An attempt may be made to preserve an eye with rupture of the sclera if the eye is only slightly collapsed through loss of vitreous. In many cases, however, immediate excision is necessary in wounds and ruptures of the sclera.

**The Indications for excision of an eye** which has sustained a perforating wound or rupture are as follows:

- (1) A large wound, particularly if the lens is injured.
- (2) Much loss of vitreous, or extensive prolapse of ciliary body, choroid or retina. Collapse of globe.
- (3) Loss of vision (no perception of light).
- (4) Evidence of the entry and retention in the eyeball of a large foreign body—more than 5 mm. in each dimension—which cannot be removed with ease.
- (5) Persistent ciliary infection, or presence of "K.P.," *without any definite diminution of these signs within fourteen days of the date of injury.*
- (6) Panophthalmitis or endophthalmitis (see p. 155).

**Foreign Bodies.**—As stated above, if the history or the clinical signs suggest the possibility of the presence of a foreign body



within the eyeball, X-ray photographs should be taken and careful localisation obtained. As in the majority of such injuries the foreign body is small, it does not usually penetrate further back than the limits of the anterior third of the eyeball. A method, recently introduced, of demonstrating the presence of a foreign body within these limits, is successful therefore in a large proportion of cases. A dental X-ray film or plate is pressed backwards, in the sagittal plane, with one corner applied to the skin on the nasal side of the eyeball. The patient may be seated or reclining. The X-ray tube is placed laterally, so as to cast the shadow of the anterior portion of the eye upon the film. By this means, even small spicules of glass have been shown to be within the eyeball. This method, however, does not localise with any accuracy. It merely demonstrates the presence of the foreign body. Types of accident which lead to the production of perforating wounds are injury to the eye during work with cold chisel and hammer, during stone-breaking, or the bursting of a bottle containing aerated mineral water, in which steel, stone, or glass respectively may enter the eyeball. Fragments of iron that penetrate the eye are frequently sterile from heating, but they are prone to cause a widespread deposit of rusty-brown colour in the iris, lens or retina, with gradual destruction of sight (siderosis). Copper almost invariably sets up a destructive inflammation. Fragments of stone are usually septic. Glass, if clean, is generally the least irritative substance, and is likely to remain in the eye without serious damage beyond that of the mechanical injury produced by its entrance. Non-magnetic foreign bodies are removed, after careful localisation, by means of delicate forceps, either through the original wound, or through an incision made in the sclerotic. If the X-rays indicate that the foreign body is small and is in such a position that its removal by forceps would be likely to cause loss of a large amount of vitreous, it may be left. In such a case the patient must be readily accessible for repeated examination. In the event of the persistence of signs of inflammation—marked ciliary injection, or “C.P.”—the eye should be enucleated, on account of the danger of sympathetic ophthalmia (see p. 163). Fragments of magnetic metal are extracted by means of the portable hand magnet, or by Haab's or Mellinger's giant magnet. The need for the use of the magnet is not common, and special technique is required in its management. The student is therefore referred to larger books for details of the use of this apparatus.



## CHAPTER V

### THE CONJUNCTIVA

#### ANATOMY

THE conjunctiva is a thin transparent membrane lined by several layers of epithelial cells. It covers the anterior third of the eyeball, is continuous with the epithelium of the cornea, and lines the posterior surface of the upper and lower lids. When the eyes are closed the conjunctiva forms a potential cavity, the conjunctival sac. The *functions* of the conjunctiva are :—

(1) That of a ball-and-socket, in conjunction with the capsule of Tenon posteriorly.

(2) The lubrication of this joint by mucous secretion.

(3) To assist the eyelids in the cleansing and protection of the cornea by mucous and lacrymal secretion.

The conjunctiva is divided into three parts, the palpebral and the ocular conjunctiva, and the conjunctival fornices. The *palpebral conjunctiva* is that which lines the eyelids, and extends from its junction with skin at the lid margins to the upper and lower fornices. It is closely attached to the tarsal plate of the upper lid, and is sufficiently transparent to enable the yellowish Meibomian glands to be seen in this situation.

The *ocular conjunctiva* is that part which, in conjunction with the corneal epithelium, covers the anterior third of the eyeball. It is loosely attached to the sclerotic except in the immediate neighbourhood of the cornea, where it is bound down. This laxity of attachment is of especial importance in the performance of operations on the eyeball, as it allows the easy covering of wounds. The blood vessels of the ocular conjunctiva are movable with this membrane over the sclerotic. The arteries are bright red in colour and can be distinguished readily from the episcleral vessels. Episcleral vessels, whether arteries or veins, are of dull red colour, owing to their covering of episcleral connective tissue, and are immovable, being buried in this tissue on the sclerotic. This fact is of use in the diagnosis of conjunctival and episcleral inflammation. Laterally the conjunctiva extends beneath the outer angle, or junction, of the upper and lower lids.



Mesially it forms a very shallow pocket beneath the semilunar fold—the third eyelid of animals—and then passes over this fold and covers the caruncle. The conjunctiva of the fornices is that part, loose and somewhat folded, which connects the palpebral with the ocular conjunctiva in the upper and lower fornices. Without this laxity and redundancy, the freedom of movement of the eyeball is limited, as in certain diseases of the conjunctiva. The upper fornix extends further back than the lower. In the conjunctiva, particularly of the upper fornix, there are, in children, numerous islands or follicles of lymphoid tissue. These follicles undergo atrophy during life.

The blood supply of the palpebral conjunctiva is mainly that of the skin of the lids. That of the ocular conjunctiva is derived from the anterior ciliary arteries, and has communication anteriorly through the anterior perforating vessels with the circulation of the ciliary body. The nerve supply of the palpebral and ocular conjunctiva corresponds with the blood supply—the palpebral conjunctiva being supplied by the nerves of the lids, the ocular by the ciliary nerves. Lymphatic drainage takes place in the direction of the preauricular lymph gland, and of a gland which lies superficially in the submaxillary triangle near the facial vessels where these cross the lower border of the mandible.

### CONGENITAL ABNORMALITIES

**Pigmented Nævus** (pigmented mole).—Histologically these growths are composed of groups or rows of cuboidal cells of epidermal origin, embedded in fibrous tissue. They are usually deeply pigmented, the pigment being situated within the cells. They occur in any situation on the ocular conjunctiva, but for the most part at or near the limbus. They are of dark brown or black colour, except in the rarer cases in which pigment is small in amount, when they are of pinkish-yellow colour.

Treatment by excision is required, either for cosmetic reasons or on account of increase in size. Occasionally they develop into malignant growths (melanotic carcinoma or sarcoma).

**Vascular Nævus**.—A congenital overgrowth of conjunctival or episcleral vessels is found usually as a small vascular nodule, rarely as a diffuse growth. Treatment, for similar reasons as for pigmented nævi, consists in excision, or the application of electrolysis or the galvano-cautery.

A **dermoid** of the cornea is a growth consisting of some of the structures of normal skin, and situated so as to override the corneo-



scleral junction. Commonly it is in the lower quadrant of the eye, of a pale pink or a yellowish colour, and oval in shape with a convex surface. It is composed of fibrous tissue, and may include hair follicles, sebaceous glands, sweat glands and fat, and have hairs projecting from its surface.

A rare abnormality is a notch in the upper lid.

### TRAUMA

Wounds, hæmorrhage, burns, see p. 91.

### INFLAMMATION

Conjunctivitis, or inflammation of the conjunctiva, is the name applied to a group of affections in which some or all of the stereotyped signs of inflammation are present, or in which certain of these signs are peculiarly modified. It may be divided into:—

(A) **Superficial or Catarrhal.**

Into this group fall types of inflammation which have several features in common.

(a) Engorgement of conjunctival vessels.

(b) A variable amount of conjunctival discharge (hence the name *catarrhal*).

(c) The presence of a causative agent (i.) in the form of a mechanical, chemical, or thermal *irritant*, e.g., foreign body, irritant vapours, rays from fire or sun; (ii.) in the form of micro-organisms.

(1) **Simple Catarrhal Conjunctivitis.**—The patient complains of symptoms of irritation of recent onset, as if there were grit or dust in the eyes. The conjunctiva is seen to be engorged, often only to a slight extent, and there may be little or no discharge, perhaps only a small yellowish crust of dried secretion at the inner canthus.

**ÆTIOLOGY.**—This, generally the mildest type of conjunctivitis, is caused by irritation from dust, wind, sun, fires, smoke or irritating vapours. Special and extreme types are snow blindness, which is an intensely painful form of inflammation of the conjunctiva due to the action especially of ultra-violet rays, and "gas" conjunctivitis which was common in the War from exposure to the irritating vapour of dichlorethyl sulphide from gas-shells.

(2) **Angular conjunctivitis** produces symptoms similar to the preceding, but it is of less sudden onset and usually of more



chronic course and longer duration. The symptoms of this disease are often out of all proportion to the signs—considerable pain being felt when there is only slight redness of the conjunctiva. Irritation is often a prominent symptom, and is usually worse in the evenings. The physical signs are distinctive in that, as the name implies, it is at the *angles* of the conjunctival sac that especial vascular engorgement occurs. The mesial and lateral parts of the white of the eye seen in the palpebral fissure, and with them the inner and outer parts of the lid margin, are particularly red. Sometimes, after long duration, there is excoriation of the skin at the outer canthus (see Fig. 74).

ÆTIOLOGY.—The causative organism is the diplo-bacillus (Morax-Axenfeld), a Gram-negative bacillus composed of two straight rods placed end to end (see Fig. 75).

(3) **Mucopurulent conjunctivitis** is usually decidedly more acute

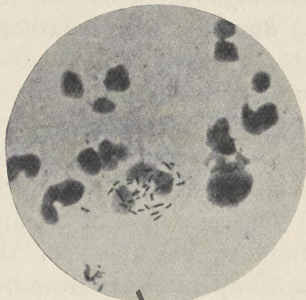
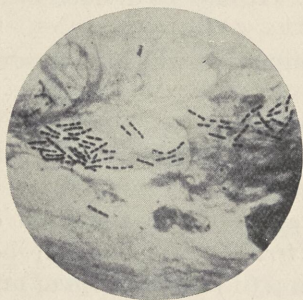


FIG. 75.—Morax-Axenfeld diplo-bacillus.

FIG. 76.—Koch-Weeks bacillus.

than either of the above, and is then accompanied by greater discomfort—burning, or even pain. Two physical signs are especially associated with it. These are (i.) mucopurulent discharge, recognised by its pale milky yellow colour and tenacious stringy nature, and (ii.) small conjunctival hæmorrhages, which are sometimes widespread and numerous (see Fig. 73).

ÆTIOLOGY.—The causative organism is the Koch-Weeks bacillus, a slender gram-negative organism, very similar to the bacillus influenzae (see Fig. 76). The disease is highly contagious, and often occurs in epidemics in schools.

**Chronic Catarrhal Conjunctivitis.**—Any of the above-described types may lead to chronic catarrhal conjunctivitis if not cured rapidly, especially the first and second. Every case which fails to yield rapidly to treatment should be examined carefully for the presence of an error of refraction, which is often sufficient to



cause this condition. In the case of *chronic monocular conjunctivitis*, careful examination should be made to exclude the presence of eversion of the lacrymal punctum, chronic dacryocystitis, ingrowing eyelashes (dystichiasis), the presence of a foreign body, or an eyelash in the lower punctum (see pp. 79, 84).

(4) **Purulent Conjunctivitis** (syn. purulent ophthalmia).—This, the most dangerous type of conjunctivitis, from the damage which it so readily inflicts on the cornea, is accompanied soon after its onset by a purulent discharge. It occurs (a) in infants, as *ophthalmia neonatorum* in which both eyes are usually affected, and (b) as *purulent conjunctivitis of the adult*, in which more commonly only one eye suffers.

**ÆTIOLOGY.**—The gonococcus, by direct infection of the conjunctiva, is the cause in 60 per cent. of cases in infants. In these,

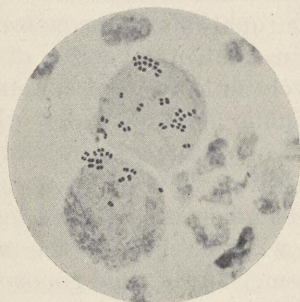


FIG. 77.—Gonococcus.



FIG. 78.—Pneumococcus.

the eyelids become contaminated with gonorrhœal discharge in the vagina during the passage of the head. The infection of the conjunctiva could be prevented in almost all these cases by careful swabbing of the child's eyelids immediately the head is born, and by the instillation of a few drops of 1 per cent. silver nitrate solution into each eye. In the adult, in most cases, one eye at a time is infected by a contaminated finger which carries the infection from the urethra or the vagina. The gonococcus is a Gram-negative kidney-shaped diplococcus and is found intra- and extracellularly in smears (see Fig. 77). The pneumococcus or the streptococcus is the cause in some cases (see Fig. 78).

(a) **OPHTHALMIA NEONATORUM.** **PHYSICAL SIGNS.**—Within two or three days of the time of birth the infant's eyelids are found to be stuck together by discharge. In those cases of definite purulent conjunctivitis in which no discharge is present until a week or more after the day of birth, the infection is probably



carried by the mother's fingers through ignorance or careless handling. On examination of a well-marked case, the eyelids are seen to be swollen and of a dusky red colour, and the lashes caked together with sticky and partly dried secretion. When the lids are separated, which is difficult if marked œdema is present, actual pus, or pus mingled with blood-stained watery discharge, escapes. Caution should be observed in separating the lids, in case infected fluid should be under pressure behind the closed lids and should be made to spurt up into the face of the examiner. The conjunctiva as a whole is intensely congested. It is œdematous, and sometimes in the condition of chemosis. The palpebral conjunctiva has a velvety appearance from swelling of the conjunctival folds and papillæ in this region. In the process of examination and particularly if a pledget of wool be applied to it, the conjunctiva exudes blood. Two further facts should be borne in mind in connection with ophthalmia neonatorum. First, the gonococcus is capable, if in small numbers or of low virulence, of producing a comparatively mild form of conjunctivitis. Secondly, for purposes of public health, under which notification is compulsory, the term "ophthalmia neonatorum" is used to include all forms of conjunctivitis having "a purulent discharge from the eyes of an infant commencing within twenty-one days from the date of its birth," whether they are the result of the gonococcus or any other organism. In the mild gonococcal cases it is difficult to demonstrate the presence of the micro-organism in smears or cultures. It follows, therefore, that a certain number of cases notified as ophthalmia neonatorum are of doubtful origin.

(b) PURULENT CONJUNCTIVITIS.—*In the adult* the condition is usually even more severe than in the infant, and is accompanied by considerable pain. As already stated, one eye alone is generally affected. Ulceration of the cornea is much more liable to occur. In other respects the clinical appearance is similar.

DIAGNOSIS.—The diagnosis of gonococcal conjunctivitis, which is of extreme importance, rests upon (i.) the severity of the disease, the presence of pus, and the tendency of the conjunctiva to bleed on manipulation of the lids; (ii.) the history or signs of vaginitis or urethritis in the mother—in the case of ophthalmia neonatorum—or of the same conditions in adult patients affected with severe conjunctivitis; (iii.) the presence of the gonococcus in smears or cultures prepared from the conjunctival discharge.



COURSE AND COMPLICATIONS.—In the vast majority of cases of purulent conjunctivitis, treated with care and patience, the inflammation subsides and the redness and discharge diminish in one to three weeks. In neglected or improperly treated cases, (i.) *ulceration of the cornea* is very liable to occur with dire results. For this reason, at each daily examination by the surgeon, the matter of paramount importance is the condition of the cornea. Usually, in the case of infants, this can only be examined with the help of a lid retractor. The first suspicion of impending ulceration is roused by a slight roughening of the surface of the cornea. This impairs the brilliancy of the image of the source of light reflected in the cornea. Next, a slight haze appears, suggesting the appearance of ground glass, or glass that has been breathed upon. At a later stage an actual loss of surface is found, which shows an irregular reflection, and stains a brilliant green on the application of a drop of 2 per cent. fluorescein. As the corneal ulceration usually affects the central part of the cornea, the vision is seriously impaired, even if the ulcer should heal without further complication. (ii.) *Perforation of the corneal ulcer* is a more serious result of gonococcal conjunctivitis. This may result in (iii.) the formation of an *anterior polar cataract* from contact of the lens with diseased cornea, but is more generally followed by (iv.) *incarceration*, or *prolapse of the iris*. In healing, shrinkage of the eye and complete loss of vision, or else stretching of the scar, and the condition known as (v.) *anterior staphyloma* may follow (see Cornea, p. 137).

PROGNOSIS.—The prognosis is good if ulceration is avoided. This depends very largely on early and regular treatment. If ulceration supervene the outlook is grave, for, in any case, vision is likely to be impaired to a serious degree by corneal opacity, and the sight may be entirely lost by perforation of the ulcer.

This disease has been dealt with at length, as, although at the present day, in countries with a well-organised health service, it causes a mere fraction of the blindness that formerly it claimed, it is one of the causes of *preventable blindness*, preventable by prophylaxis and by early and efficient treatment of the disease when this is established.

(5) **Membranous conjunctivitis** is a rare form of catarrhal conjunctivitis, in which exudate is coagulated on the surface, usually of the palpebral conjunctiva, so as to form a membrane, or sometimes, in addition, within the layers of the conjunctiva,



so as to render this membrane stiff and thickened. It is due more often to the streptococcus than to the diphtheria bacillus.

TREATMENT OF CATARRHAL CONJUNCTIVITIS.—In general, the following precautions should be adopted for all forms of conjunctivitis :—

(i.) The patient should be advised to bathe the eyes with the help of a small piece of lint or pledget of wool, which can be burnt after use ; to bathe the better eye first, and to use separate pieces of lint or wool for each eye ; periodically to boil droppers and eyecups, if used.

(ii.) The eye should be kept uncovered in order to avoid the retention of harmful secretion within the conjunctival sac, which would prove an excellent incubator for micro-organisms.

(iii.) Cocaine, as a means of relieving pain or discomfort, *should be avoided* as it is harmful to the corneal epithelium. Adrenalin, also, although it blanches the conjunctiva for a time after each application, should only be used for cosmetic reasons, as it sometimes assists in prolonging chronic conjunctivitis.

For *acute cases* (i.) frequent cleansing of the conjunctival sac is essential, by means of warm boracic lotion, grs. x. to the ounce, or, if this prove irritating, by warm normal saline. (ii.) The application, at intervals of one, two, or three days, according to the severity of the case, of 1 per cent. or 2 per cent. silver nitrate solution in distilled water. This causes the desquamation of superficial cells of the conjunctival epithelium, and the removal with them of numerous offending micro-organisms. This solution should not be dropped into the eye for fear of causing injury to the cornea. It should be applied to the palpebral conjunctiva and fornices by a pledget of cotton wool wrapped around a thin glass rod. The excess of silver nitrate is quickly neutralised by the sodium chloride in the tears. Exfoliation of superficial conjunctival epithelium by means of silver nitrate solutions should be employed in the case of infections due to parasitic organisms only. These include the gonococcus, pneumococcus, and Koch-Weeks bacillus. The diplo-bacillus of Morax-Axenfeld acts as a saprophyte and lives only on dead epithelial cells, which have been shed. Angular conjunctivitis is not, therefore, likely to be improved in the least degree by such treatment. (iii.) A bland greasy application, such as sterile vaseline or boric acid ointment should be applied in small quantity along the lid margins at night to prevent their adhesion and to allow secretions to escape during the night. As a substitute for the application of



silver nitrate solution to the conjunctiva, a few drops of 10 per cent. argyrol may be introduced into the conjunctival sac three times daily after bathing. Three minutes after the use of the drops the eyes should again be bathed, in order to avoid excessive epithelial desquamation. The danger of argyrosis—staining of the conjunctiva by silver—by the prolonged use of silver salts, contra-indicates the use of any of them for more than three weeks at a time. During the actual treatment of such cases nurses should wear goggles in order to obviate the danger of infection to their own eyes.

In *chronic conjunctivitis*, trichiasis, eversion of the punctum, lacrymal obstruction and errors of refraction must first be treated, if present (see pp. 79, 84). Care should be taken to eliminate all possible causes of irritation of the eyes, as enumerated under the heading of simple catarrhal conjunctivitis. Careful examination of the upper part of the cornea for pannus, and of the upper palpebral conjunctiva for scarring, is necessary in order to disclose the signs of trachoma, in which special treatment is required (see below). Of local applications one of the most helpful is zinc sulphate, either as a lotion, gr. i. combined with boric acid grs. x. ad  $\mathfrak{z}$ i., or as drops, gr. i. ad  $\mathfrak{z}$ i. Periodical changes of the drugs used are essential, as the conjunctiva fails to respond after prolonged use of the same application. Instead of the zinc salt, liquor hamamelidis  $\mathfrak{z}$ ss. ad  $\mathfrak{z}$ i., alum grs. ii. ad  $\mathfrak{z}$ i., or glycerinum acidi tannici  $\mathfrak{M}$ viii. ad  $\mathfrak{z}$ i., may be used.

For angular conjunctivitis drops of zinc sulphate, grs. ii. ad  $\mathfrak{z}$ i., applied three times daily, and the ointment as prescribed below, prove efficacious: ichthyol grs. ii., zinc. oxide grs. iii., lanoline  $\mathfrak{z}$ i., vaseline flav. ad  $\mathfrak{z}$ ii.

TREATMENT OF PURULENT CONJUNCTIVITIS. — As already stated, the greatest importance attaches to the prevention of corneal ulceration. Among poor patients special institutional treatment has proved the most efficacious manner of dealing with this disease. In the London area, under the control of the Metropolitan Asylums Board, St. Margaret's Hospital, Kentish Town, N., admits both child and mother whenever possible, as this, by helping to keep up the child's general condition, aids towards recovery from the conjunctival inflammation. The great essential is the regularity and frequency of the treatment. In a bad case the conjunctiva is irrigated every hour with cold eusol, 1 in 7, and receives the instillation of a drop of acriflavine in castor oil, 1 in 1,500, afterwards. Home treatment should consist in



the frequent cleansing of the eyelids and of the conjunctival sac in order to remove discharge and prevent adhesion of the lids. The actual drug used is of less importance than the regularity and frequency of its use. Boric acid lotion or 1 in 8,000 perchloride of mercury serves equally well. The conjunctiva should be painted every one or two days with silver nitrate solution of 1 per cent. or 2 per cent. strength. Boric acid ointment should be applied along the lid margins at night. A daily inspection of the cornea is necessary until the inflammation begins to subside, in order to ascertain that its surface maintains its smooth and glossy

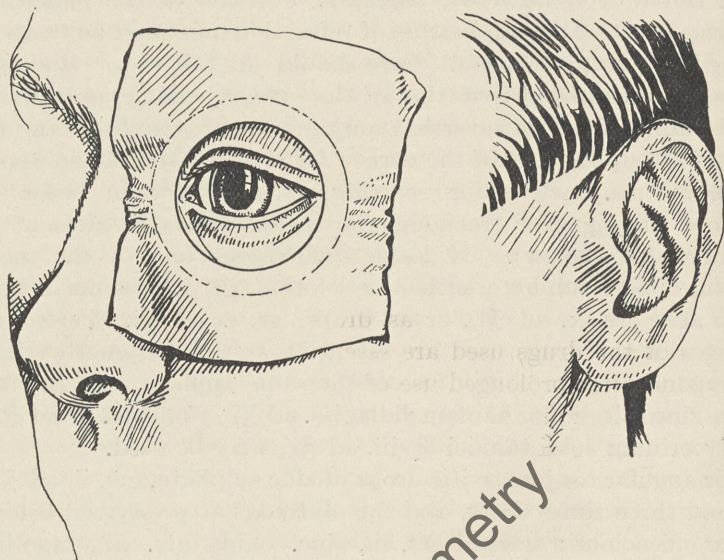


FIG. 79.—Buller's shield for the protection of a healthy eye when the fellow eye is affected with purulent conjunctivitis.

character. If there should be the least suspicion of roughening of the cornea, extreme measures should be taken to ensure that more skilled and regular bathing be obtained. If, as is usually the case in adults, only one eye is involved, every effort should be made to prevent the infection of the other. To this end the patient should be confined to bed in a well-ventilated room, and lie on the affected side, with a Buller's shield fixed over the sound eye to protect it from inadvertent fingering (see Fig. 79). Further, a prophylactic application to the healthy eye of a few drops of some organic silver preparation should be made each day. For the relief of pain in the early stages, leeches may be applied to the temple, cold compresses of boric acid to the eye,



and frequent bathing with cool boric lotion employed. Aspirin, or even opium, may be necessary. If the eyelids swell so much that they become very tense, the external canthus should be divided. When the stage of suppuration supervenes, bathing with warm boric lotion and painting with silver nitrate solution are desirable.

(B) **Interstitial Conjunctivitis.**

This comprises those types of inflammation which involve the deeper or connective tissue layers of the conjunctiva as well as the epithelial.

This group, therefore, includes :—

- (1) Follicular conjunctivitis (lymphoid tissue overgrowth).
- (2) Tuberculous conjunctivitis
- (3) Trachomatous conjunctivitis (trachoma) } (granulomata).
- (4) Spring catarrh (mainly fibrous tissue proliferation).
- (5) Phlyctenular conjunctivitis, which is described separately, as the cornea is involved in a similar manner with or without the conjunctiva (see p. 123).

(1) **Follicular Conjunctivitis.**—Follicles of the conjunctiva are minute collections of lymphocytes situated immediately beneath the epithelium. They are present to a variable extent in the conjunctiva of healthy children. In over 50 per cent. of apparently healthy county council school-children follicles have been found on the conjunctiva. They occur as minute pale papules projecting from the conjunctiva, either scattered if few in number, or in rows if numerous. They are most evident in the lower fornix, fewer in number over the lower tarsal conjunctiva and in the upper fornix. In other cases their presence is associated with an acute catarrhal conjunctivitis, or with a mild chronic form of inflammation of considerable duration. In the latter circumstance they resemble sometimes mild cases of trachoma (see Fig. 81, Plate IV., p. 116).

TREATMENT should be adopted as for catarrhal conjunctivitis, with attention to the general health and the correction of even small errors of refraction. The prognosis is good.

(2) **Tuberculous conjunctivitis** (syn. *lupus conjunctivæ*) is of comparatively rare occurrence. It is sometimes associated and continuous with lupus vulgaris of the skin of the lid. Sometimes it occurs as the only discoverable tuberculous lesion in the body; in others in association with definite tuberculosis elsewhere. Clinically it is seen as an ulcerated area on the palpebral conjunctiva covered with greyish-red granulations, or in a form



with an exuberant growth of red granulations reminiscent of a cock's comb.

Treatment includes every artifice for the improvement of the general health, and, locally, excision or curetting of granulations and the application of the galvano-cautery to the raw area.

(3) **Trachoma**<sup>1</sup> is a contagious conjunctivitis of long duration, and liable to bring in its train many troublesome complications.

**ÆTIOLOGY.**—The frequency of its occurrence varies with poverty and squalor. It is prolific among North African races, in Russia, and in Eastern European countries. Among other countries of Europe it is mainly limited to the slum districts. It affects children and adults alike. Thanks to the establishment of special trachoma schools for the isolation and treatment of children affected with the disease, it is now a comparative rarity among children in London.

**SIGNS AND SYMPTOMS.**—Trachoma has two stages: (1) the acute stage, or the stage of granulations; (2) the chronic or regressive stage, or the stage of cicatrization.

In the *stage of granulations*, there is a history of symptoms of conjunctivitis of some duration, of irritation or a feeling of grittiness in the eyes, and of slight discharge. Examination reveals a diffuse redness of the conjunctiva, mainly palpebral, a velvety appearance of the palpebral conjunctiva due to enlargement of the normal papillæ, and a variable number of gelatinous-looking rounded nodules scattered over the upper and lower palpebral conjunctiva (Fig. 83). The largest nodules are usually situated along the upper border of the upper tarsus. They are relatively soft to the touch and their contents are capable of being expressed with forceps. In appearance they bear some resemblance to the ova of frog spawn. In the later part of this stage an encroachment upon the cornea by the conjunctival vessels of the limbus takes place, especially in the upper part. In this way a curtain of delicate blood vessels is gradually drawn down over the upper part of the cornea. To a less extent it may occur in other portions of the cornea. The vessels are quite superficial in the early stages of this condition of *pannus*. With the longer duration of *pannus* the affected part of the cornea becomes hazy, and finally in severe cases develops a yellowish-white opacity<sup>2</sup> (see Fig. 102 Plate VI., p. 140).

In the second or *regressive stage* the granulations have dis-

<sup>1</sup> τραχύς = rough.

<sup>2</sup> Pannus = a cloth.



appeared, and a distinctive form of scarring affects the conjunctival surface of the upper lid. On the everted upper lid is seen a grey-white line, due to scar tissue, parallel with the margin of the lid and 1 to 3 mm. from it (Fig. 84). Elsewhere on the conjunctiva faint bluish-white marks and lines of scar tissue may be visible, and scarring of the fornix and ocular conjunctiva is accompanied by shrinking of this membrane, so that the fornices become shallower than normal, and bands or folds of conjunctiva are seen stretched between the eyeball and the lids when the eye is moved in different directions. Thus is produced one form of

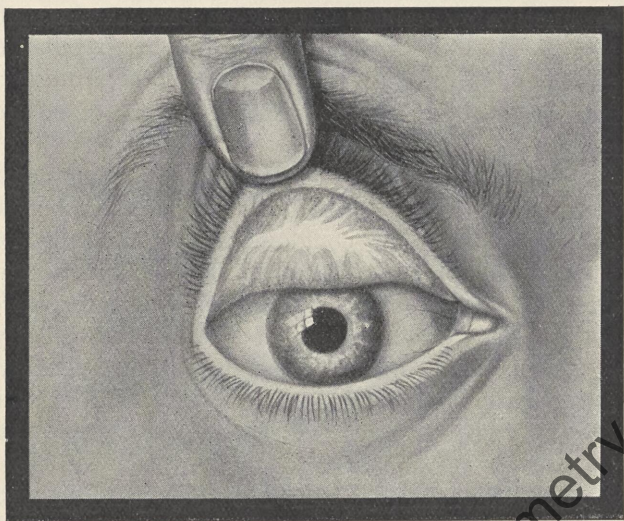


FIG. 84.—Scarring of conjunctival surface of upper lid in long-standing trachoma. (From a drawing in Museum of Lond. Sch. of Hygiene and Trop. Med.)

symblepharon. At this stage of the disease pannus of the cornea is fully established. Chronic conjunctivitis may persist for many years, with its symptoms of discomfort and slight discharge, unless rigorous and painstaking treatment be continued.

COMPLICATIONS AND SEQUELÆ.—1. *Lids*.—*Blepharitis* is common, secondary to chronic conjunctival inflammation. This is often followed by *trichiasis* or irregularity in the direction of the lashes, so that some turn inwards and rub the cornea and conjunctiva. This causes considerable discomfort and occasionally leads to ulceration of the cornea. *Entropion*, especially of the upper lid, is a common com-



plication, resulting mainly from the scarring of the conjunctiva and of the tarsus beneath it.

2. *Conjunctiva*.—*Scarring* and *symblepharon* and the sequela *entropion* have already been mentioned. For *xerosis* of the conjunctiva, see p. 122.

3. *Cornea*.—*Pannus*, with a variable degree of opacity, may cause serious diminution of visual acuity (see Fig. 102, Plate VI., p. 140). *Ulceration* sometimes results from rubbing of the cornea by ingrowing lashes.

**PATHOLOGY.**—*Conjunctival papillæ* on the upper tarsus, producing the velvety appearance noted above, are due to thickening of the conjunctiva by cellular infiltration beneath the epithelium and by exaggeration of the normal microscopic papillæ, or folds and depressions, present in this situation. A similar velvety appearance is produced in other chronic types of conjunctival inflammation.

*Granulations* are most common in the upper fornix, and should strictly be termed *granulomata*. They are beneath the epithelium and consist in conglomerations of cells with ill-defined limits, except in older granulations which develop a fibrous capsule. An isolated granulation is usually surrounded by plasma cells, has an outer zone of small round cells (lymphocytes) and a central mass of mononuclear (epithelioid) cells, among which are usually some phagocytic cells containing deeply-stained bodies; these have no connection with "inclusion bodies," which are granules within the cytoplasm of large mononuclear cells. Inclusion bodies are not pathognomonic of trachoma, for they are also found in purulent and in some cases of Koch-Weeks (mucopurulent) conjunctivitis. They are either degeneration products, stainable by a special technique, or represent a micro-organism present as a mixed infection with other specific organisms.

Cellular infiltration affects all the tissues involved in trachoma. It invades the upper tarsus from the conjunctiva and in its replacement by scar tissue in the healing process causes shrinkage and distortion of the tarsus, obliteration of Meibomian glands, and scarring of the conjunctiva. By the same process it involves the lid margin, destroys lash follicles and ciliary sweat glands (Moll), and causes general atrophy and rounding-off of the borders of the lid margin.

*Pannus* is found histologically to consist in cell-infiltration and vascularisation between the corneal epithelium and Bowman's



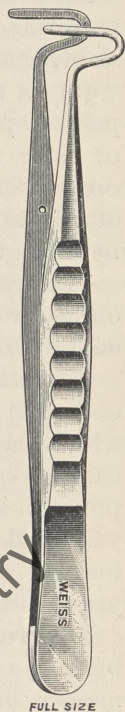
membrane. In late stages the cell-infiltration is replaced by fibrous tissue, which causes permanent corneal opacity.

**DIAGNOSIS.**—The most important disease which may be confused with trachoma is follicular conjunctivitis (see p. 123). The follicles in follicular conjunctivitis are smaller, more superficial, *i.e.*, project more abruptly above the conjunctival surface, are often arranged in lines like beads on a thread, are mainly confined to the lower lid, and never cause conjunctival scarring or pannus. Cell inclusions are never found in follicular conjunctivitis, while they are commonly found in well-established cases of trachoma. Sometimes it is only possible to determine the diagnosis after observing the progress of the disease. Trachoma is distinguished from spring catarrh by the presence, in a typical case of the latter, of eosinophiles in the conjunctival secretion and of hard granulations arranged like paving stones, on the palpebral conjunctiva.

**PROGNOSIS.**—The prognosis of the majority of cases of trachoma is fairly good, subject to the important condition that treatment be carried out regularly and efficiently over a prolonged period. The institutional treatment of trachoma in trachoma schools has been highly successful in checking the disease and preventing its complications, as well as in arresting its dissemination. The treatment of adult cases, however, in hospital out-patient departments does not prove so successful, because on slight signs of amelioration patients tend to neglect further treatment until a serious recrudescence compels them to obtain further attention.

The majority of the complications cause discomfort and inconvenience rather than incapacity. The most dangerous to vision are pannus and corneal ulceration, and in a certain number of cases pannus advances and opacifies the cornea to a very serious extent in spite of most patient and rigorous treatment.

**TREATMENT.**—(1) *In the Stage of Granulations.*—Three main methods are employed. They are sometimes used alone, or may be combined. (a) Expression of the granulations, under free cocaineisation, with Tyrrell's forceps (see Fig. 85), followed by repeated painting of the affected conjunctiva with 2 per cent.



FULL SIZE

FIG. 85.—  
Tyrrell's  
trachoma  
forceps.

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silver nitrate solution and the frequent use of boric acid lotion. (b) Scarification of the conjunctiva and, after a few days, brushing or rubbing, repeated at regular intervals, with 1 in 500 perchloride of mercury, and the frequent use of 1 in 7,000 perchloride lotion. (c) Cauterisation of special regions with the Paquelin or galvano-cautery, particularly the conjunctiva at the upper border of the tarsus when this is the seat of prolific granulations.

An extract of jequirity beans—an extremely irritant fluid—is useful as an occasional application to the conjunctiva in cases showing an especially dense type of pannus.

(2) *In the Regressive Stage.*—Copper sulphate in the form of a pointed pencil of bluestone is applied to the conjunctiva once or twice weekly, and zinc sulphate (1 or 2 per cent.) lotion or drops are used three times daily, or, as an alternative, an ointment of citrate of copper (grs. xx. ad ʒj.) once daily, with repeated bathings with boric acid lotion.

The treatment of the various complications should be carried out according to the directions given in the various sections which deal with those subjects.

(4) **Spring catarrh** (syn. conjunctivitis vernalis, conjunctivitis aestivalis) is a proliferative inflammation of the conjunctiva of which the cause is unknown. It is rare and occurs mostly in children or young adults. As its name implies, it is particularly prone to appear in the spring or during the warm months of the year, and it recurs with regularity for several years. It is a self-limiting disease which, in the course of a variable number of years, diminishes in severity and finally ceases.

**SYMPTOMS AND SIGNS.**—The patient complains of a hot, burning or irritating sensation and a slight amount of stringy mucous discharge. There are two clinical types: (a) *Palpebral*, confined to the conjunctiva of the lids, particularly the upper, on which pinkish nodules of irregular size and shape are found projecting from the tarsal conjunctiva. If the nodules are numerous and set closely together, they have the appearance of irregular paving stones, for each one affects by pressure the shape of its neighbours. The nodules are firm as they are mainly composed of fibrous tissue in the surface of which are irregular downgrowths of conjunctival epithelium. (b) *Ocular*. In this, the rarer type in the British Isles, a fringe of finely nodular jelly-like excrescences is set around the limbus, or in some cases larger swellings may be present on one portion only of this region. The colour is usually paler than in the first variety. In both forms



there is one important feature, namely, that the conjunctiva has a milky-white appearance, being less transparent than usual, and as though a thin film of diluted milk lay over the whole surface. Smears from the conjunctiva usually contain an abundance of eosinophile leucocytes.

DIAGNOSIS is made by consideration of the history, the presence of nodules—particularly on the upper tarsal conjunctiva or around the limbus—the milky-white appearance of the conjunctiva, and the presence of eosinophiles in smears from the conjunctiva. From *trachoma* it is distinguished by the hardness of its nodules, by the absence of vascular pannus at the upper part of the cornea, and by the absence of scarring of the tarsal conjunctiva.

TREATMENT is usually of little avail in altering the duration of the affection. Radium application has been used frequently, and has been followed by improvement or recovery in some cases, but has been devoid of the slightest effect in other cases. The application of a hazeline lotion, M xxx. ad  $\bar{z}$ j., or the frequent instillation of weak acetic acid drops—1 part of dilute acetic acid in 10 of distilled water—relieves the irritation to some extent. Change of climate during the warm season is sometimes efficacious. Many patients are made more comfortable by wearing tinted goggles, *i.e.*, spectacles with solid side-pieces.

### DEGENERATION OF THE CONJUNCTIVA

**Pinguecula** <sup>1</sup> is the name given to a fold of conjunctiva which is raised up near the nasal or temporal margin of the cornea in persons of middle age who have led a life of exposure to wind or dust. It lies parallel with the palpebral fissure and has a yellowish colour, from which fact arose the name. It is of no clinical importance (see Fig. 86).

A **pterygium** <sup>2</sup> is a triangular-shaped flattened prominence of whiter colour than the former, which occurs in a similar situation (see Fig. 87). It occurs in middle-aged people particularly in tropical countries, and from an early stage encroaches upon the cornea. The extension of a pterygium is mainly over the cornea, so that in an advanced stage it encroaches on the pupillary area and interferes seriously with vision. Various operations have been devised for the removal of the growth and plastic repair of the

<sup>1</sup> *Pinguis* = fat.

<sup>2</sup> *πτερυξ* = wing.



defect. In most cases recurrence takes place, and repeated operations are necessary.

**Xerosis** of the conjunctiva is a degenerative change in which the surface of this membrane becomes dried. It usually occurs in patches, in which the conjunctiva is thickened, is opaque white in colour, and loses its elasticity. It develops (1) in severe cases of trachoma; (2) in exposure due to ectropion or cicatrisation of the lids from any cause. As a rare occurrence it is a manifestation of general malnutrition.

### NEW GROWTHS OF CONJUNCTIVA

#### (A) Simple New Growths and Cysts.

New growths of the conjunctiva are uncommon. The least rare are: (1) **A dermoid**, which occurs at the corneo-scleral junction and involves the surface of both structures, usually in the inferior temporal region. This growth is congenital and usually remains stationary in size. It is oval in shape, and pinkish in colour, with a slightly convex surface raised above the level of the surroundings. It may be removed for cosmetic reasons.

(2) **A Pigmented Nævus**.—This is generally much smaller than the former, is situated near the limbus, usually to the temporal side, is in the conjunctiva and freely movable with it, and is congenital. It is of a red to dark brown colour. In the later years of life it may enlarge, in which case it should always be removed freely, for occasionally a malignant tumour arises from a nævus. It is probable, in fact, that all malignant melanotic tumours have their origin in such growths.

Other simple tumours of the conjunctiva which are still more rare are papilloma, fibrous polyp, granuloma, angioma.

**Cysts**.—An *implantation cyst* may arise from slight trauma with a sharp object in the exposed part of the ocular conjunctiva. A *cyst* of one of *Krause's* accessory lacrymal glands occurs in the upper or lower fornix. A *lymphatic cyst* is formed by dilatation of a lymph vessel, usually in loculi arranged like a few beads strung together.

(B) **Malignant new growths** are extremely rare. They are carcinomata or sarcomata. In either case the growth is almost invariably centred at the limbus and extends over the cornea and over the sclerotic. In each a striking feature is the number and size of the blood vessels which pass to the growth. A



carcinoma is pale pink or grey-white in colour; a sarcoma is usually dark brown or black or piebald. One type of carcinoma spreads as a thin, flat growth, whereas a sarcoma is almost always prominent.

TREATMENT.—If either form of growth is seen in an early stage—for example, when not more than 5 mm. in diameter, and especially if it is somewhat movable on the surface—it should be shaved off from the surface of the globe with a thin layer of underlying sclera and cornea. The base is then treated with a heavy dose of radium. In growths of moderate size excision of the eyeball is necessary, and in particularly large growths exenteration of the orbit should be performed.

In the case of carcinoma with lymphatic gland enlargement the affected pre-auricular or submaxillary lymph glands should be excised as freely as possible. The prognosis in such cases is very serious.

# PHLYCTENULAR CONJUNCTIVITIS AND KERATITIS<sup>1</sup>

(Syn. conjunctivitis eczematosa, C. scrofulosa, C. pustulosa.)

DEFINITION.—Phlyctenular kerato-conjunctivitis is an inflammation of the conjunctiva or cornea, or of both, which is characterised by the development of localised nodules or papules composed of lymphocytes with surrounding areas of vascular engorgement, which are also usually localised (see Fig. 83, Plate V., p. 121).

ÆTIOLOGY.—It occurs in children or young adolescents, chiefly between the age of four and fourteen years. It is almost entirely limited to the hospital class of patient, and occurs particularly in children debilitated by the exanthemata. Tuberculosis is a cause in some cases, and the nodules are due to tubercle bacilli or toxins carried endogenously to the site affected. In other cases a septic focus, such as inflamed tonsils and adenoids, or disease of a nasal sinus, is a cause. The disease has probably an anaphylactic basis, whereby the eye becomes sensitised to the presence of quite minute proportions of tuberculous or other toxins.

SIGNS AND SYMPTOMS.—In the older patients, who are able to describe their symptoms, there is often little complaint apart from the redness and slight watering of the eyes. In the younger cases there is more commonly, especially when the cornea is

<sup>1</sup> φλυκταινα = bladder, pustule. The name is erroneous, as it is now known that the swelling does not contain fluid.

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involved, very great photophobia, blepharospasm and lacrymation, so that the typical picture is presented of a small child with its face buried in its mother's skirts. In a mild case examination reveals one or two pinkish nodules, about 1 mm. in diameter, at or near the limbus, with engorged blood vessels passing towards them from different directions. The situation is variable and may be in any part of the ocular conjunctiva or of the cornea. Very rarely is the palpebral conjunctiva affected. The commonest site is at the limbus, or near this on the conjunctiva or cornea. If the nodules are few in number, each one has its own localised area of engorgement. If, however, they are distributed in some number around the cornea, the whole of the conjunctiva may be intensely red. In the course of a few days the epithelium covering the summit of the nodule sloughs and leaves a tiny ulcer raised up above the level of the surroundings. The introduction of a drop of 2 per cent. fluorescein into the conjunctival sac picks out the ulcer by a bright yellow colouration if the lesion is placed over the sclerotic, or with a green colour if on the cornea. Gradually the ulceration erodes the nodule until it is level, and then the floor becomes free from slough and is quickly healed over by epithelial growth. The course of a phlyctenule on the conjunctiva and at the limbus is similar. A phlyctenule which is isolated on the surface of the cornea will not show signs of healing until new-formed blood vessels have grown out to it from the conjunctival vessels. These are usually seen as a leash or bundle of vessels, and in this stage the condition is often referred to as *fascicular keratitis*. The most dangerous type of phlyctenule is that which from the beginning is obviously deep in the cornea. As it develops, it raises the corneal surface over it, changes from grey to yellowish colour, and presently leads to sloughing of the surface and the formation of a deep ulcer. Such a deep ulcer is very liable to perforate. Thus there are three main types of phlyctenule: the superficial phlyctenule, on the conjunctiva or at the limbus; the superficial form, on the cornea; and the deep corneal lesion.

**PATHOLOGY.**—A simple lesion consists in a collection of lymphocytes, closely aggregated in the connective tissue beneath the conjunctival epithelium or deep to the corneal epithelium, and generally as deep to Bowman's membrane (see Fig. 88). When the covering epithelium has sloughed and become separated there is an ulcer with its surface infiltrated with polymorphonuclear leucocytes, so that in the ulcerated stage leucocytes are mingled



with the lymphocytes. In the case of a deep corneal lesion, when the progress of the inflammation has ceased, the floor of the ulcer is cleaned by separation of necrotic substantia propria, and the ulcer healed by the formation of granulation or scar tissue and the growth of epithelium over this from the edges of the ulcer. In this case the scar tissue is of importance, as it leaves a dense corneal opacity. If the phlyctenule is superficial to Bowman's membrane no visible scar results, and no interference with vision, even should the ulcer be situated over the pupillary area.

COMPLICATIONS.—The course of a simple conjunctival or limbal phlyctenule is described above. Sometimes the disease is protracted, particularly in the case of the superficial corneal type, by the formation of fresh crops of phlyctenules or by extension

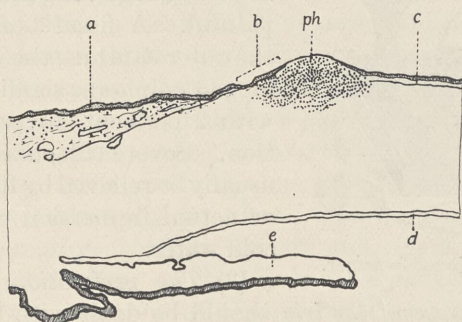


FIG. 88.—Phlyctenule at the limbus. Antero-posterior section of corneo-scleral junction and iris. (a) Conjunctival epithelium; (b) limbus; (c) Bowman's membrane; (d) Descemet's membrane; (e) iris; (ph) phlyctenule.

of the lesion. In this way a large area of the cornea may be traversed during the course of several years. The complications are: (i.) corneal nebulae and irregular scarring of the surface, so as to impair vision. This impairment is in some cases extremely serious in degree, especially if dense opacities are situated in the pupillary area. (ii.) In deep corneal ulceration perforation of the ulcer, with consequent prolapse of iris, may occur. If the iris prolapse is not treated satisfactorily by early operation, (a) intra-ocular infection and panophthalmitis, or (b) healing with anterior synechiae, later anterior staphyloma or glaucoma, may supervene (see Cornea, pp. 137, 217). In any of these eventualities the vision is likely to be lost.

TREATMENT.—(A) LOCAL. (1) *Conjunctivitis and slight or moderate corneal lesions.* Boric acid lotion irrigation, the application of calomel powder or of 1 per cent. unguentum hydrargyri



oxidi flavi may be employed. The latter should not be used when there is more than slight vascular engorgement. The eye should not be bandaged.

(2) *Deep corneal ulceration*.—In this condition, or whenever there is much ciliary or circumcorneal injection, drops of atropine sulphate should be used and dark glasses worn. The application of heat by frequent hot bathing, or by means of a small hot bottle held over the closed eye, or by the electric hot pad (see Fig. 89), gives relief. In the event of obvious extension of the ulcer

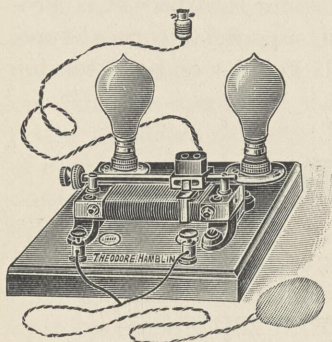


FIG. 89.—Electric eye-warmer.

or by the actual cautery, should be employed (see pp. 135, 136). In the more severe cases the eye may be kept bandaged if blinking is at all painful. A fissure of the skin at the outer canthus, the result of prolonged epiphora, should be painted with 2 per cent. silver nitrate solution. Severe blepharospasm may usually be relieved by liberal bathing or actual immersion of the face in cold water.

(3) *The perforation of a corneal ulcer and prolapse of the iris* should be dealt with by abscission of the prolapsed iris, as in iridectomy (*vide* p. 268).

(B) GENERAL.—Abundant plain food should be provided, with freedom from sweets or sugar. Fresh air and, if possible, a visit to the country often suffice to produce a rapid recovery. Tonics containing iron, arsenic or quinine should be prescribed. Syrupus ferri iodidi and cod-liver oil are useful. Iodides should not be used if calomel is being employed locally. Attention should be paid to any local affections of teeth, tonsils, ear, nose and throat. This is extremely important, for removal of an obvious source of sepsis, such as enlarged, inflamed tonsils, sometimes acts like magic in long-standing cases that have resisted all other forms of treatment.



## CHAPTER VI

### CORNEA AND SCLEROTIC

#### ANATOMY OF THE CORNEA

THE cornea is the clear window let into the anterior portion of the eyeball. It is elliptical when viewed from in front, being 12 mm. in horizontal and 11 mm. in vertical diameter. Its thickness is approximately 1 mm. In health it is perfectly transparent and has a beautifully smooth polished surface, on which the brightness of the eye is largely dependent. It is continuous with the sclera laterally and has a greater convexity of its anterior surface, as it possesses a shorter radius of curvature than the sclera. The cornea is overlapped to a slight extent by the sclerotic, in a manner somewhat similar to the overlap of a watch-glass by its rim. The somewhat ill-defined line of demarcation between cornea and sclera, as seen from the outside, is known as the *limbus conjunctivæ* and corresponds with the junction of the conjunctiva with the corneal epithelium.

The microscopic examination of the cornea reveals five layers in antero-posterior section (see Fig. 90).

(1) *The epithelium* is stratified and is continuous with the conjunctival epithelium.

(2) *Bowman's membrane* is a thin layer of homogeneous connective tissue which blends with the tissue deep to it, namely—

(3) *The substantia propria of the cornea.* This forms the bulk of the thickness of the cornea and is continuous laterally with the sclerotic. Although it is transparent in health, it is composed of bundles of white fibrous connective tissue which possess exactly similar histological features to those of the sclerotic. These fibres are arranged mainly parallel to the surface, and in successive lamellæ pass in different directions.

(4) *Descemet's membrane* is a very thin, homogeneous elastic layer which covers the back of the cornea and is connected laterally with the pectinate ligament of the iris.



(5) The *endothelium* is formed of a single layer of flattened cells and covers the posterior surface of Descemet's membrane. Its cells extend laterally over the fibres of the pectinate ligament and on to the iris.

The cornea is dependent for its nutrition mainly on numerous vascular loops formed at the corneo-scleral junction from the anterior ciliary vessels, as it is in health an avascular structure. Lymph is capable of passing throughout its structure by minute channels or lymph spaces. The nerve supply is derived from the

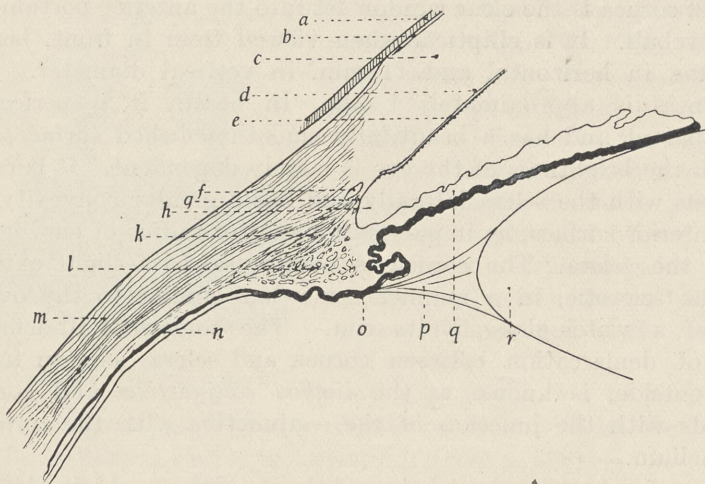


FIG. 90.—Sagittal section of periphery of cornea and of anterior part of eye. (a) Corneal epithelium; (b) Bowman's membrane; (c) substantia propria; (d) Descemet's membrane; (e) endothelium of cornea; (f) canal of Schlemm; (g) ligamentum pectinatum iridis; (h) angle of anterior chamber; (i) radial portion of ciliary muscle; (j) circular portion of ciliary muscle; (k) sclerotic; (l) pars plana ciliaris; (m) summit of ciliary process; (n) suspensory ligament of lens; (o) iris; (p) lens.

ciliary nerves and from the nerves to the bulbar conjunctiva. These form a rich plexus in the superficial layers of the substantia propria, and another between the epithelium and Bowman's membrane. Loss of part of the epithelium as by an abrasion, and superficial lesions such as phlyctenules on the cornea, are therefore usually very painful owing to exposure or irritation of the sub-epithelial plexus.

For methods of examination of the cornea, see p. 8.

TRAUMA (see p. 98).



## INFLAMMATIONS

DEFINITIONS.—*Edema of the corneal epithelium* is a condition of relatively diminished outflow or drainage of fluid. It produces clinically diffuse haziness of the cornea, some loss of polish or of power of reflection of the surface visible to the naked eye, and minute bullæ visible through a lens as slightly raised, dark, clear spots in surrounding haze. It is found typically in acute glaucoma, but also in certain inflammations to a slight degree, e.g., interstitial keratitis.

*Edema of the substantia propria* is also a condition in which the tissue is waterlogged. It is detected on examination with a lens by the presence of faint grey-white lines, often more or less

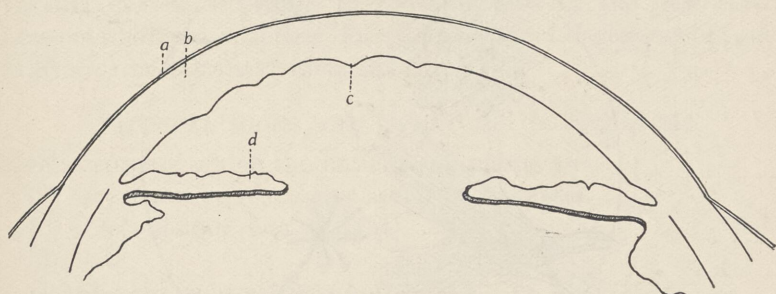


FIG. 91.—Edema of the substantia propria. Antero-posterior section of cornea, etc. (a) Epithelium; (b) substantia propria of cornea; (c) a fold of Descemet's membrane representing the transverse section of a ridge which projected backwards into the anterior chamber. Four similar ridges are shown. In concentrated focal illumination these ridges so reflect the light that they appear as delicate lines or striae. (d) Iris.

parallel. Careful examination with a  $\times 10$  magnification lens for parallax indicates that the lines affect the deepest strata of the cornea (see Fig. 91). It occurs in various inflammations, e.g., mild inflammation following extraction of cataract, inflammation in wounds of the cornea, interstitial keratitis.

*Infiltration of the cornea* is the presence of inflammatory cells in the cornea. These cells gain access to the cornea by escaping from normal blood vessels at the corneo-scleral junction, or from newly formed vessels developed in the substance of the cornea during inflammation. These cells are commonly polymorphonuclear leucocytes in acute inflammations and small lymphocytes in chronic inflammations. Clinically, infiltration is seen as a more or less localised grey-white haze or opacity. In severe ulcers or badly infected wounds of the cornea it is of yellowish colour



(see Hypopyon Ulcer, p. 132). Examples of a less acute type of infiltration are (i.) a phlyctenule of the cornea in phlyctenular keratitis, and (ii.) the infiltration in interstitial keratitis. Slight degrees of infiltration often leave no trace, but dense infiltrations, either with or without ulceration of the surface, leave permanent opacities.

*Vascularisation of the cornea* takes place by the formation of new vessels which grow from marginal vascular loops either (1) superficially or (2) deeply. Superficial vessels are formed in

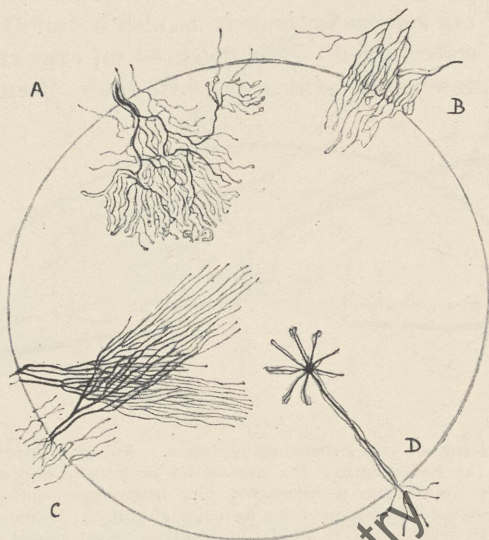


FIG. 92.—Superficial and deep corneal vessels. A and B, superficial vessels continuous with conjunctival vessels; freely branching. C, deep vessels appear at limbus in groups of brush-like form. (Holmes Spicer, *Brit. Jl. Ophth. Monograph* 1924.)

ulceration of the cornea, and as pannus in trachoma, while deep vessels occur particularly in interstitial keratitis, tuberculous keratitis, and in deep ulceration.

(1) Superficial vessels—

- (a) Are continuous with conjunctival vessels ;
- (b) Are brighter red in colour ; and
- (c) Branch freely and widely, with some resemblance to the branches of a tree (see Fig. 92).

(2) Deep vessels—

- (a) become visible only at the margin of the cornea, and appear from beneath the limbus.
- (b) Are dull red or bluish-red in colour.



- (c) Frequently course in parallel bundles towards the centre of the cornea, taking a brush-like form. Lastly, the difference in depth may be detected by very careful examination with a  $\times 10$  magnification lens for parallax.

*Opacities of the cornea* are classified according to their intensity or the degree to which they render the affected part opaque. A haze of the cornea is described as a *nebula*, an opacity of extreme density as a *leucoma*,<sup>1</sup> an opacity of intermediate degree as a *macula*. In the strict sense of the term an opacity implies the presence of a fixed or unchanging condition, and is therefore to be distinguished from an infiltration. The majority of opacities are the result of ulceration of the cornea. They indicate the presence of new fibrous tissue or scar tissue, which is opaque in varying degree according to the thickness of the new tissue. Less common are opacities due to products of degeneration, such as hyaline or calcareous deposits.

#### PHYSICAL SIGNS AND SYMPTOMS OF KERATITIS

SYMPTOMS of which the patient complains are :—

- (1) Lacrymation (excessive secretion of tears).
- (2) Photophobia (fear of light).
- (3) Pain.
- (4) Blepharospasm (spasm of the lids).
- (5) Impairment of vision.

The severity of the symptoms is not by any means always a measure of the gravity of the lesion. Frequently superficial lesions of the cornea, which involve the nerve endings or superficial nerve plexus, cause more marked symptoms than deeper lesions.

PHYSICAL SIGNS :—

- (1) Infiltration of the cornea.
- (2) Ulceration, with impairment of the natural polish of the surface.
- (3) Vascularisation of the cornea.
- (4) Circumcorneal injection.
- (5) Often accompanied by conjunctivitis, iritis or cyclitis.

CLASSIFICATION.—Keratitis, or inflammation of the cornea may be divided into—

#### (A) Keratitis with Ulceration or Loss of Surface.

- (1) Following trauma.
- (2) Phlyctenular keratitis (see p. 123).

<sup>1</sup> λευκος = white.



- (3) Secondary to acute or chronic conjunctivitis :  
     Gonococcal conjunctivitis.  
     Chronic catarrhal conjunctivitis.
- (4) Serpiginous ulcer (syn. hypopyon ulcer, ulcer serpens).
- (5) Dendritic ulcer ; also  
     Mooren's ulcer, and  
     Neuropathic : (a) Herpes zoster.  
                     (b) Neuroparalytic.

(3) **Ulceration Secondary to Conjunctivitis.**

- (a) In *gonococcal conjunctivitis* (see p. 110), as already stated, warning of impending ulceration in infants or in adults is given by the presence of a slightly roughened appearance or loss of polish of the corneal surface, similar to that produced by breathing upon glass. In infants ulceration can almost always be prevented by frequent bathing and the avoidance of sticking together of the lids by discharge.

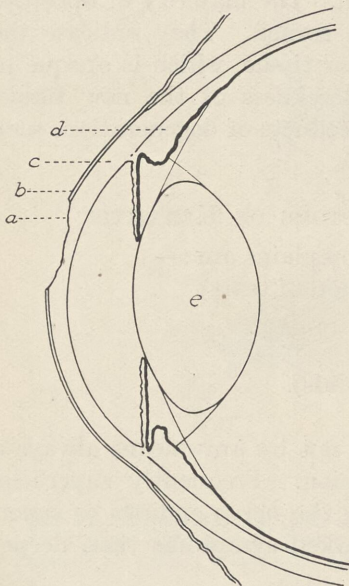


FIG. 93.—Simple corneal ulcer. Antero-posterior section. (a) Ulcer floor; (b) corneal epithelium; (c) substantia propria; (d) ciliary body; (e) lens.

(b) Catarrhal ulceration of the cornea is a complication of *chronic catarrhal conjunctivitis*. It occurs as a small crescent-shaped ulcer or ulcers near the margin of the cornea in debilitated elderly people. Treatment of the conjunctivitis combined with attention to the general health is usually sufficient to bring about recovery, but in

intractable cases local treatment of the ulcer is necessary.

(4) **Serpiginous Ulcer.**

(Syn. Hypopyon ulcer, *ulcus serpens*.) This form of ulcer is so named on account of its tendency to spread over the cornea.

**ÆTIOLOGY.**—It occurs usually in elderly persons from among the poorer classes. The pneumococcus is usually found, often in association with lacrymal obstruction and the presence of a

<sup>1</sup> *Serpo* = I creep.



mucocoele. In such circumstances a trivial injury, as from a piece of grit blown into the eye, may be the exciting cause.

**PATHOLOGY.**—Sections of an eye affected with a serpiginous ulcer show—

(1) Loss of substance of the cornea (see Figs. 93 and 94) and the necrotic badly-stained floor of the ulcer infiltrated with polymorphonuclear cells.

(2) A zone of infiltration of the substantia propria in the neighbourhood of the ulcer, especially on the side which is nearest to the corneal margin.

(3) The presence of a collection of pus in the lower part of the anterior chamber—a hypopyon.

(4) A variable amount of cellular infiltration of the iris and ciliary body.

(5) In recovering cases, vascularisation, mainly of the more superficial layers of the substantia propria.

(6) In healed cases, an epithelial covering, of irregular thickness, over a flattened or slightly depressed layer of cellular fibrous tissue. The latter—scar tissue—is the cause of the dense corneal opacity which results from ulceration. It fills up in part the marked depression caused by necrosis and sloughing of the substantia propria, but leaves the cornea thinner than normal in the affected area.

**SYMPTOMS AND SIGNS.**—All the symptoms and signs enumerated

above are present in a typical case of serpiginous ulcer. The extent of the ulcer can be detected by careful examination of the surface by means of a lens and oblique illumination, but is displayed more clearly by the application of a drop of fluorescein, which stains it green. In addition, the collection of pus in the lower part of the anterior chamber is seen as a yellowish mass with a horizontal, flat upper surface. Naturally it

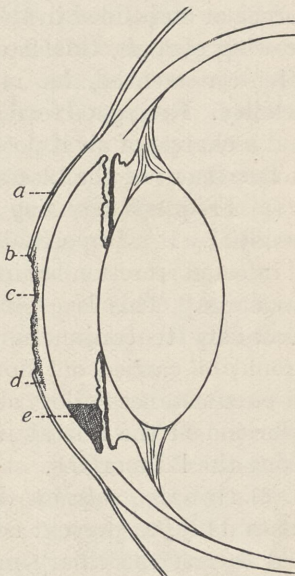


FIG. 94. — Serpiginous or hypopyon ulcer of the cornea. Vertical antero-posterior section of front of eye. (a) Corneal epithelium; (b) margin of ulcer; (c) floor of ulcer with infiltrated substantia propria beneath; (d) zone of infiltration beyond margin of ulcer; (e) hypopyon, or collection of pus in the lower part of the anterior chamber.



obscures completely the lower part of the iris (see Fig. 95, Plate VI., p. 140).

DIAGNOSIS.—The presence of a corneal ulcer with a hypopyon settles the diagnosis.

TREATMENT OF ULCERS OF THE CORNEA.—If any local cause is present at the time of examination, such as a foreign body on the cornea or embedded in the upper palpebral conjunctiva, or an ingrowing eyelash, this should be removed. General treatment is often an essential, for many ulcers are largely due to general debility. Rest, good food, tonics, sunshine or “artificial sunlight,” and a change of air if possible, should be prescribed.

Treatment of the ulcerated cornea is as follows :—

(1) Frequent *cleansing* of the eye with warm boracic lotion is essential. It is important to ensure that there is no accumulation of infected secretion behind lids which are glued together by dried discharge. This is especially to be observed in cases of ulcer secondary to conjunctivitis, *e.g.*, gonococcal, in which bathing should be carried out hourly during the day, and as frequently as circumstances allow at night. To assist in the prevention of adhesion of the lids at night, boracic ointment can be smeared along the lid margins.

(2) *Atropine sulphate drops* (1 per cent.), to be applied three times daily, to prevent adhesions of the pupil margin to the lens and to rest the ciliary muscle. Careful watch should be maintained on the tension of the eye in elderly people, on account of the danger of the occurrence of glaucoma as a result of full dilatation of the pupil. In doubtful cases, when the pupil is well dilated, a  $\frac{1}{2}$  or  $\frac{1}{4}$  per cent. solution of atropine sulphate may be used.

(3) The application of a dry pad and *bandage* is to be avoided in all cases of corneal ulceration secondary to conjunctivitis, as it tends to aggravate the latter. In other cases it gives rest to the ulcer by avoidance of friction by the lid. If no bandage is used, dark glasses should be worn.

(4) The *application of heat* is of great utility. It can be used (i.) by the systematic steeping of the eye in very hot saline lotion for twenty minutes at a time three times daily ; (ii.) the application of dry heat by a small hot-water bottle, a sandbag, or by means of an electrically-heated pad. Concurrently with the application of heat by one of these methods, the frequent cleansing of the eye should be continued in the intervals.

(5) *Cauterisation of the ulcer* is necessary if the ulcer extends in



spite of the treatment above described. It can be performed by (a) painting with carbolic acid. While the lids are maintained in a position of separation the affected area of the cornea is carefully dried by the point of a triangular piece of blotting paper. The whole area of the ulcer, and particularly its margin, is gently touched and stroked with the sharpened point of a pine stick or wooden match previously moistened in pure liquid carbolic acid. The area so treated becomes opaque white from coagulation. The eye is then flooded with lotion to remove excess of the acid, and some sterile vaseline or atropine ointment is inserted between the lids. (b) An electrically-heated instrument, a thermophore, has recently been devised for the direct application of definite degrees of heat to corneal ulcers. By this means greater control is available in the application of heat well below that of the instrument next to be mentioned.

(c) The electro-cautery is used with the points of the instrument at a dull red heat, and the floor and margin of the ulcer are thereby seared.

(6) Intractable cases of serpiginous ulcer are sometimes arrested by *corneal section*. In this operation a cataract knife is inserted through non-ulcerated cornea at one side of the ulcer, and the point brought out through the cornea beyond the opposite margin of the ulcer. The blade of the knife is then carried forwards in a plane at right angles to the corneal surface through the centre of the ulcer. It thus divides the whole of the thickness of the cornea between *a* and *b*. Incidentally, the collection of pus is expressed from the anterior chamber by manipulation of the cornea with an iris repositor.

COMPLICATIONS of severe ulceration of the cornea are :—

(1) Suppuration within the eye—*panophthalmitis*—which, as its name implies, involves purulent infiltration of all the coats of the eyeball as well as of its contents. Its presence is notified by great pain in the eye, extreme congestion with chemosis of the conjunctiva, redness and œdema of the lids, general malaise and pyrexia. The treatment of the condition is enucleation of the eyeball (see p. 259).

(2) In deep ulceration of the cornea the whole thickness of the substantia propria is occasionally lost over a small area by sloughing, so that only Descemet's membrane remains. The normal tension of the eye causes this elastic membrane to bulge and project as a clear vesicle above the surface of the cornea. This is known as a *keratocele*. The occurrence of this condition is



usually heralded by relief of pain, owing to reduction of ocular tension. It is of urgent importance in that a timely paracentesis of the anterior chamber through a healthy part of the cornea may prevent perforation of the ulcer. On the first appearance of a keratocele paracentesis should be performed, and repeated, if necessary, in twenty-four or forty-eight hours. It is very doubtful if the application of a firm bandage to an eye affected with a deep ulcer of the cornea or early keratocele is of the least benefit. When the eyes are closed they rotate upwards, so that the cornea is directed as much upwards as forwards. In an ulcer in any position other than the lower third of the cornea it is likely that

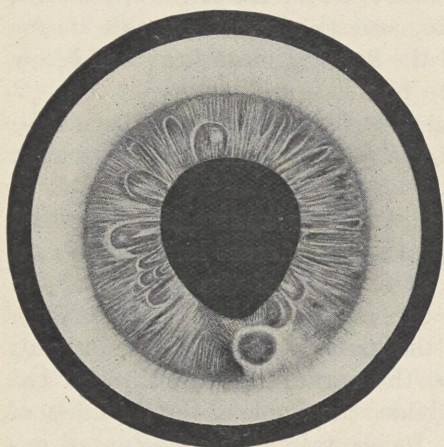


FIG. 96.—Leucoma adherens. Corneal opacity below, with iris drawn up to it and pupil dragged peripherally. Result of deep corneal ulcer, with bulging of Descemet's membrane.

[Drawing by Hamblin.]

a firm bandage increases the risk of perforation by compression of the sclerotic. In every case of deep ulcer great care should be exercised during examination. When perforation is threatened in a *peripheral* corneal ulcer, or if actual perforation has occurred not more than a few hours previously, so that the iris is only caught up into the deep lips of the wound, the administration of eserine sulphate drops ( $\frac{1}{2}$  per cent.) half hourly sometimes draws the iris back into position. This is the only circumstance in which a myotic should be used. In all other cases atropine or other mydriatic should be employed.

(3) *Perforation* of the cornea may follow the formation of a keratocele, or may take place suddenly. In the leakage of aqueous which results gradually or rapidly, the iris is carried forwards to lie in contact with the cornea. If the ulcer be situated so that the iris comes to lie in contact with the perforation either *incarceration* or *prolapse* of the iris may result. In the former, after sealing of the perforation is established, the iris remains caught in the lips of the wound at one place. When the anterior chamber is refilled by aqueous the iris is drawn forwards somewhat in the form of a tent, with the summit of the tent adherent to



the corneal wound. A dense opacity is produced with healing of the ulcer, with a dark spot in the centre due to the iris. This condition is then known as *leucoma adherens* (see Fig. 96). When

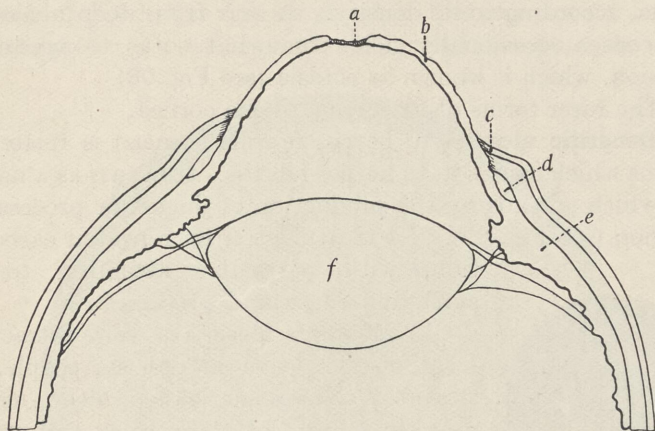


FIG. 97.—Complete prolapse of iris in wide perforation of ulcer of the cornea. Antero-posterior section of front of eye. (a) Pupillary membrane; (b) prolapsed iris; (c) cornea at margin of perforation; (d) remains of anterior chamber; (e) ciliary body; (f) lens.

the area of necrosis and the size of the defect in the cornea are large, almost the whole of the iris prolapses and occupies the aperture (see Fig. 97). If in such a case the inflammation eventu-

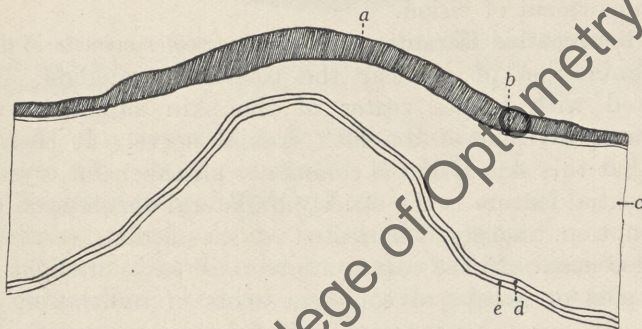


FIG. 98.—Ectasia of cornea following healing of an ulcer. Antero-posterior section of part of cornea. (a) Thickened epithelium at site of ulcer; (b) Bowman's membrane at margin of ulcer (it has been destroyed at the site of the ulcer); (c) substantia propria; (d) Descemet's membrane; (e) endothelium.

ally subsides without the necessity for excision of the eye, the iris becomes incorporated in the scar tissue which takes the place of the cornea. Such scar tissue is gradually stretched as the tension



of the eye returns to, or exceeds the normal. Eventually this new "cornea" may become markedly prominent, and the condition of *anterior staphyloma* may be produced.

(4) A *scar* of the cornea may be a nebula, a macula or a leucoma, according to its density. A scar from deep ulceration of the cornea occasionally yields somewhat, so as to produce a protrusion, which is known as *ectasia* (see Fig. 98).

(5) The rarer forms of ulceration of the cornea.

(i.) **Dendritic ulcer** (syn. *herpes febrilis corneæ*) is related, in the virus which causes it, to *herpes febrilis*. It occurs as a narrow ulcer, which spreads by the production of fingers or processes of ulceration (see Fig. 99). Its treatment is by repeated carbollisation, with particular attention to the spreading edges and processes.

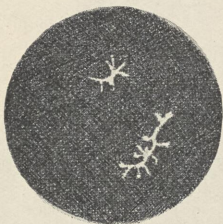


FIG. 99.—Dendritic ulcer of cornea.

(ii.) **Mooren's ulcer** is a very intractable form of ulceration in elderly people. It starts as a crescent-shaped ulcer, usually near the margin of the cornea, and spreads slowly but steadily towards the centre, and often completely across the cornea, in spite of the most vigorous treatment. The distinctive feature of its spread is the undermining of the advancing edge which

takes place (see Fig. 100). It destroys about half the thickness of the cornea, without perforation, and naturally results in great impairment of vision.

(iii.) **Neuropathic Keratitis.**—(a) *Herpes zoster corneæ* is due to an inflammation in or near the Gasserian ganglion, and is associated with herpes zoster of the skin supplied by the ophthalmic division of the fifth cranial nerve. It should be noted that this skin lesion is commonly mistaken for erysipelas. The essential feature is the strictly unilateral distribution of the skin eruption, sharply demarcated at the median vertical line of the forehead. In the cornea are seen, in early or slight cases, small spots or groups of confluent spots of infiltration at its surface. In more severe cases the affected areas become ulcerated. There is not infrequently iritis of marked degree.

(b) *Neuroparalytic keratitis* occurs after operations upon the Gasserian ganglion or the fifth cranial nerve root, and is due partly to trophic causes and partly to damage from undue exposure of the insensitive and unduly delicate cornea. The earliest sign of the onset of the condition is a faint haziness, with



loss of polish of the surface of the cornea. This soon gives place to ulceration. The treatment should be prophylactic, namely, tarsorrhaphy or partial closure of the lids for a time after operations on the fifth nerve. The same treatment is adopted if ulceration follows the operation when this precaution has not been adopted. In addition, bathing and atropine should be

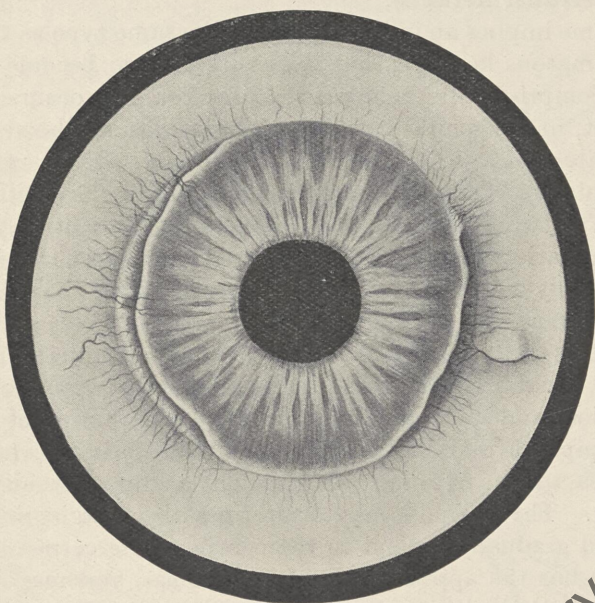


FIG. 100.—Mooren's ulcer. The illustration shows ulceration of a narrow zone on each side of the cornea, with slight vascularisation of this area and undermining of the mesial edge of the ulcer. [Drawing by Hamblin.]

employed. Cauterisation in any form should be most stringently avoided in any case of neuropathic keratitis.

(B) **Keratitis without Surface Loss.**

(Keratitis parenchymatosa in the widest sense.)

- (1) Interstitial keratitis (congenital or rarely acquired syphilis).
- (2) Tuberculous keratitis (syn. tuberculous parenchymatous keratitis).
- (3) (Rare) Deep keratitis, disciform keratitis, probably related, sometimes the result of a small superficial wound or abrasion, or of a contusion, usually of unknown cause.

The name parenchymatous keratitis includes various forms of inflammation mainly of the substantia propria, or "parenchyma"



of the cornea. Several diseases due to specific infections are capable of producing it. In man syphilis, tuberculosis and leprosy may show themselves in this manner. In animals an analogous affection of the cornea frequently occurs as in dogs affected with distemper and in many animals with trypanosomiasis. It is usually a physical sign or a local manifestation of a general disease.

(1) **Interstitial Keratitis.**

The name implies an inflammation of the same type as the term parenchymatous keratitis, but it has by custom become limited so as to comprise only the syphilitic affection. It occurs, for the most part, in congenital syphilis and, during childhood, as one of the latest manifestations of this disease. It is rarely an accompaniment of the secondary stage of acquired syphilis in the adult. The two forms are, in general, similar, excepting that the congenital variety is sooner or later bilateral, whereas the acquired affects usually only one eye. The description given below applies to the commoner congenital variety.

**SYMPTOMS AND PHYSICAL SIGNS.**—The inflammation starts with the usual irritative symptoms of keratitis, photophobia, lacrymation, and some pain in one eye. Examination of the eye reveals epiphora and slight ciliary or circumcorneal congestion. The cornea, in an early stage, shows slight haziness, usually in the periphery. The haziness may start from the margin in several places and gradually extend to the centre of the cornea, so that the whole has the appearance of ground glass, and may become so opaque that the iris cannot be distinguished. The vision may then be reduced to mere perception of light. The surface is seen with a lens to be slightly irregular, like the surface of an orange. With the advance of the opacity from the periphery towards the centre, there is developed a new formation of blood vessels which grow into the cornea. A fringe of bright red superficial vessels from the conjunctiva is seen covering the circumferential parts. Dull red, brush-like mainly parallel deep vessels from the ciliary arteries in the sclerotic advance right to the centre of the cornea (see Fig. 92). The gross appearance of a highly vascularised area is such that it is described as a *salmon patch*. The opacity of the cornea, then, usually spreads inwards from the periphery. The vascularisation follows suit. With the vascularisation come, presumably, more powerful means of dealing with the infection, and hence a clearing up of the opacity, also starting in the periphery. The centre of the cornea retains a denser degree of opacity to the last (see Fig. 103). The *acute stage* of active infiltration of



the cornea lasts for from four to eight weeks, and with its end the irritative symptoms become less marked. In all except the mildest cases iritis or iridocyclitis is present (see p. 156).

The *chronic stage*, with milder inflammatory symptoms and signs, lasts from a few months to over a year.

**PATHOLOGY.**—In the stage of infiltration, the cornea in section shows the presence of groups or masses of lymphocytes in the deeper layers of the substantia propria (see Fig. 105). In severe cases the infiltration is so intense that necrosis of a considerable part of the deeper layers of the substantia propria takes place. In the process of healing, new layers of connective tissue are laid down, which lie less regularly than the normal lamellæ. In the cornea of an established or old case, deep vessels are present also between the deeper lamellæ. There is usually evidence of iritis or iridocyclitis in addition.

**DIAGNOSIS.**—The diagnosis is made on the presence of an acute keratitis passing into a chronic stage, with widespread infiltration and vascularisation of the deeper layers of the substantia propria. It is confirmed by the presence of other stigmata of congenital syphilis, and by the Wassermann reaction, which is positive in most cases. Other signs of congenital syphilis are parietal nodes, bosses of the frontal bone, depressed bridge of nose, deafness, radiating scars at the angles of the mouth, Hutchinson's teeth, defective first permanent molars with rounded crowns, synovitis of the knee joint, nodes on the tibia, epiphysitis, and, lastly, active gummatous ulcers. Occasionally the signs of old disseminated choroiditis are found in the opposite eye.

If there are no stigmata of congenital syphilis, investigation of the history and family history for tuberculosis, and

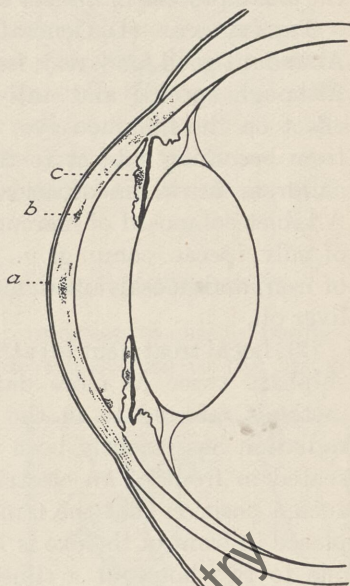


FIG. 105.—Interstitial keratitis. Antero-posterior section of the front part of an eye in the active stage, in which some iritis was also present. (a) Corneal epithelium; (b) focus of round-celled infiltration in the substantia propria; (c) nodule of round-celled infiltration in the iris.



careful examination for signs of tuberculosis elsewhere should be made.

COURSE AND COMPLICATIONS.—As already stated, the disease is often very chronic, so that as much as two or even three years may elapse before there is the fullest possible recovery of vision. Iritis and iridocyclitis are common accompaniments of the keratitis. After a few weeks or months the other eye undergoes the same process in almost every case.

TREATMENT.—(1) General hygienic treatment is very necessary. Abundant good food, rest, fresh air and tonics should be provided. Although specific and anti-syphilitic treatment has very little effect on the inflamed eye, and does not prevent the other eye from becoming subject to the disease, it should be employed in children, in whom occasionally gummatous lesions arise later. A tablet composed of mercury and chalk, with an equal quantity of pulv. ipecac. comp. gr. i., twice or thrice daily, syrup of iodide of iron, and neosalvarsan, may be given in conjunction with cod-liver oil.

(2) Local treatment (*a*) atropine, as 1 per cent. drops of atropine sulphate twice or more daily. (*b*) Heat. In addition to the methods referred to in the treatment of corneal ulcers, direct radiation has recently been strongly advocated. The patient is seated in front of an electric heater with a copper reflector, in such a position that the temperature recorded by a thermometer placed in front of the eye is 125° C. The heat is applied for from one to two hours at a time, and is found to relieve pain to a remarkable extent.

PROGNOSIS, as far as vision is concerned, is fair in more than half the cases, and bad in only a very small proportion. Hope of improvement in visual acuity may be maintained up to three years.

(2) **Tuberculous keratitis**, and (3) **Deep keratitis** and **disciform keratitis** resemble interstitial keratitis in their appearance, but usually involve a portion of the cornea rather than the whole, and affect one eye only.

DIAGNOSIS.—In *tuberculous keratitis* there is usually a localised tuberculous lesion in the eye elsewhere, a nodule of scleritis, a nodule or mass of tuberculosis in the ciliary body, or in the root of the iris, from which infiltration extends into the cornea on the side affected. In such cases the following signs will indicate the diagnosis:—(1) A brawny bluish-red swelling of the sclera. (2) A small irregular pupil with adhesions of



the pupil margin to the lens capsule (posterior synechiæ), the presence of a yellowish mass arising from the anterior surface of the iris or visible blood vessels on the iris. (3) Abundant coarse "mutton-fat" deposits of "K.P." (keratic precipitates) on the deep surface of the cornea, or a mass of yellowish-white exudate in the lower part of the anterior chamber. Furthermore, in a certain proportion of cases, signs or symptoms suggestive of the presence of tuberculosis elsewhere in the body will be found.

*Deep keratitis* affects the deeper layers of the cornea diffusely or locally. *Disciform keratitis* occurs as a circular, usually central, opacity (see Fig. 101, Plate VI.). In each the cause is rarely found. Occasionally a contusion, or a slight corneal abrasion with infection of the wound, produces the condition. Both are rare.

TREATMENT of the affected eye should be carried out as for interstitial keratitis.

### DEGENERATION AND OTHER ANOMALIES

**Arcus Senilis.**—In a considerable proportion of elderly people a narrow grey-white line of opacity develops close to the margin

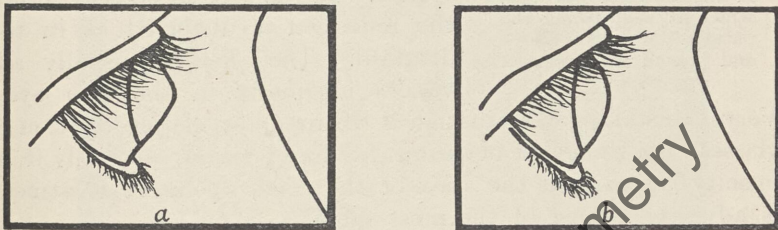


FIG. 106.—Conical cornea. (a) Lateral view of eye affected with conical cornea; (b) lateral view of normal eye.

of the cornea. It begins in the upper and lower quadrants, and in extreme cases extends all round. It is separated from the sclera by a narrow band of almost clear cornea (see Fig. 109). It is due to the deposition of fat globules in Bowman's membrane and in the superficial layers of the substantia propria. It has no effect upon vision.

**Conical Cornea.**—The central part of the cornea is unable to withstand the normal intraocular tension, and becomes stretched. This occurs in a very small proportion of young women and more rarely in men. The cause is unknown. It is likely that a predisposition results from debility following a serious illness, but it is sometimes present in perfectly healthy adults. Probably



there is some congenital weakness of the substantia propria. In advanced cases the conical shape of the cornea may be detected in

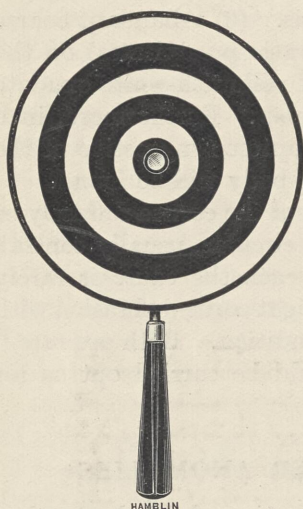


FIG. 107.—Placido disc. The eye is examined through a small aperture in the centre of the disc, which is held facing the patient. A light is above and behind the patient's head.

the examination of the eye in profile (see Fig. 106). In slight cases, suspicion is raised by an abnormal appearance of the red reflex in the performance of retinoscopy, and by the presence of a high degree of astigmatism, the correction of which by glasses fails to restore normal vision. It is confirmed by inspection of the cornea through Placido's disc (see Figs. 107, 108). A lamp is placed above and behind the patient's head. The observer stands directly facing the patient and inspects the eye at a distance of about 1 foot, by looking through the aperture in the centre of the disc. The reflection of the rings marked on the disc is seen in the cornea. In the case of conical cornea the reflection is distorted as in the diagram. The affection usually advances unequally in the two eyes.

Very painstaking examination is required for the prescription of glasses. In the event of serious failure of vision, especially if an opacity appears at the apex of the cone, operative treatment is advisable. One of the most satisfactory procedures is cauterisation of the apex to induce contraction and flattening of the cone, followed by optical iridectomy (see p. 273). The prognosis is very variable.

*Pannus* of the cornea occurs as an inflammatory change in *trachoma* (see p. 116 and Fig. 102, Plate VI., and as a degenerative change in eyes blind from severe injuries or inflammation. In the two conditions the eye presents a similar appearance, with a variable degree of grey-white opacity, and superficial blood vessels which are continuous with the conjunctival vessels.



FIG. 108.—Distortion of image of Placido disc in a conical cornea.



## ANATOMY OF THE SCLERA

The sclera (sclerotic), in conjunction with the cornea, forms the outer or fibrous coat of the eyeball. It is white externally, slightly brownish internally from adherent choroidal pigment. The bluish-white colour sometimes noticeable in the white of the eye, particularly in children, is due to greater thinness of the sclera, whereby this structure is less opaque, and its colour is influenced by the choroidal pigment beneath it. It is about 1 mm. in thickness, and by its inelasticity and toughness maintains the shape of the eyeball. Posteriorly, 2.5 mm. to the nasal

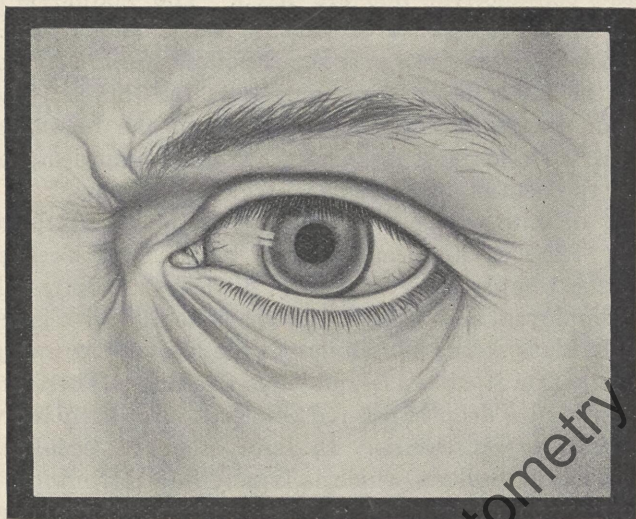


FIG. 109.—Arcus senilis corneae. [Drawing by Hamblin.]

side of the posterior pole, it is perforated by the optic nerve. The space through which the nerve passes is bridged by scleral fibres, which form the *lamina cribrosa*. Through the interstices of this lamina pass the bundles of nerve fibres. The outer layers of the sclerotic are continuous with the dural sheath of the optic nerve. The sclera is covered by conjunctiva and by Tenon's capsule. Vascular episcleral tissue connects the conjunctiva loosely with the sclera. The four rectus muscle tendons are inserted into it anteriorly, the two oblique muscles posteriorly. Between its deep surface and the choroid is the supra-choroidal lymph space. It is perforated by three sets of blood vessels, (1) anterior



ciliary, (2) *venæ vorticosæ*, (3) posterior ciliary, in the ciliary equatorial and posterior regions respectively.

### TRAUMA (see p. 98)

### INFLAMMATIONS

(1) **Episcleritis**, or inflammation of the episcleral connective tissue, is always associated with some degree of inflammation of the superficial layers of the sclera. It is recognised by a tender boss or nodule of pinkish-yellow colour, with dull red or violet engorged blood vessels on its surface. These vessels do not move with the conjunctiva, but are fixed. The nodule is usually situated on the sclera at or near to the ciliary region. It is distinguished, in the case of a small nodule, from a phlyctenule, in that the latter is very commonly at the limbus, whereas a nodule of episcleritis does not extend so far forwards. The condition is sometimes associated with rheumatism, or with sepsis in the dental, aural, or nasal regions or throat.

If any definite source of sepsis can be found this should be treated. The local application of dry heat, and of leeches to the skin of the temple, relieves pain. Aspirin or sodium salicylate may be employed, and attention to the general health is required.

(2) **Scleritis** is somewhat similar to the above, but owing to its deeper situation it causes less obvious swelling. There are pain, tenderness and a deep bluish-red colouration, usually more widespread than in episcleritis. In later stages a peculiar violet colour affects the sclera, which is largely due to thinning of this layer owing to destruction and absorption. Some degree of transparency then allows the ciliary and choroidal pigment to deepen the colour. Still later there is commonly some stretching of the thin violet-coloured scar, and the development of a bulge—a *staphyloma of the sclera*—even though the ocular tension remain normal. The diagnosis is confirmed by the greater severity and extent of the inflammation, and by the involvement of other structures. There is commonly *iritis* with posterior synechiæ, *cyclitis* with the deposit of "K.P." on the back of the cornea, *choroiditis* with vitreous opacities, or an extension of inflammation into the cornea, known as *sclerosing keratitis*. The latter is detected by invasion of the cornea from the most inflamed area of sclerotic with deep infiltration. The grey-white clouding of the cornea which accompanies this infiltration is replaced in the



healing process by dense fibrous tissue. As a result a porcelain white opacity of the cornea is produced, continuous with the affected region of the sclera. This gives the appearance as of extension of the sclera into the cornea. Both eyes are usually affected, but not necessarily simultaneously. The cause of scleritis is usually tuberculosis or syphilis, but occasionally a focus of sepsis, as in episcleritis, is at the root of the matter.

Treatment, apart from general measures, and specific treatment of the cause if this be found, is unavailing. Iodides, iron, or tuberculin injections may be given, according to the general condition.

**Staphyloma<sup>1</sup> of the Sclera** (*cf.* staphyloma of cornea, p. 137; see also *glaucoma*, p. 214).—Protrusion of the sclera occurs usually as the result of yielding of the scars of wounds or inflammation. An *anterior staphyloma* of the sclera occurs behind the corneo-scleral junction, where the sclera is weakened by the passage of the tributaries to the anterior ciliary veins, or of the anterior ciliary arteries. It is developed often without any increase in ocular tension, although the preceding wound or inflammation is liable to produce glaucoma by means of anterior synechiæ.

An *equatorial staphyloma* of the sclera takes place at the equator of the eye in the region where the passage of the *venæ vorticosæ* weakens it. It is also due to wounds or inflammation of the sclera.

A *posterior staphyloma* is usually a sequela of high myopia, in which the posterior pole of the eyeball becomes stretched to the temporal side of the optic disc.

<sup>1</sup> σταφυλος = bunch of grapes; -ωμα = swelling.



## CHAPTER VII

### IRIS, CILIARY BODY AND CHOROID

#### ANATOMY

The *uvea*, composed of three parts, the iris, ciliary body and choroid, is the middle or vascular coat of the eye, internal to the sclerotic or fibrous coat, and external to the sensory or retinal coat, whose outer layers it nourishes.

The *iris* is a coloured diaphragm with a circular aperture placed centrally. It is situated in front of the lens, and in contact with the lens capsule by its pupillary or free border (see Fig. 90). Peripherally it is attached to the ciliary body and the ligamentum pectinatum iridis. It divides the aqueous chamber in which it is placed, into an anterior and a posterior chamber. Its anterior surface possesses a distinctive colour, which is dependent upon the amount of pigment cells in the stroma. A blue iris has a deficiency of pigment cells in its stroma, although it possesses the normal double layer of pigment epithelium to form its posterior surface. The anterior surface shows a distinctive pattern, which is less marked in a brown than in a blue or grey iris. It is composed mainly of wavy radiating lines, with others arranged more or less concentrically with the pupil lying anterior to these a short distance from the pupil margin. The pattern is obscured in iritis, and changed or lost in atrophy of the iris. Inequality in the pigmentation is common. The layers of the iris are :—

- (1) Anterior endothelium.
- (2) Stroma, composed of loose connective tissue, a variable number of pigmented cells, blood vessels and nerves.
- (3) The muscles of the iris : (a) The sphincter pupillæ, a 1-mm. wide annular layer in front of the pigment epithelium close to the pupil margin, and (b) the very thin delicate layer of radially arranged muscle fibres of the dilator pupillæ lying in close contact with the pigment epithelium peripheral to the sphincter. The sphincter is innervated by the third nerve, the dilator by the sympathetic.
- (4) The two layers of pigment epithelium cells. The pupillary border of this pigmented layer is normally visible under magnification as a very narrow dark-brown line at the pupil margin, where



it projects mesially to the stroma. These two layers of epithelium correspond with the two embryonic layers of the optic cup, one of which forms the retina and the other the single layer of retinal pigment epithelium.

The *ciliary body* is that part of the uveal tract between the iris in front and the choroid behind. It is exposed, in dissection of the eye by equatorial section, after the lens has been removed and the retina pulled away from its anterior attachment. The line at which the retina is torn away is the *ora serrata*, the junction between choroid and ciliary body. In viewing the inside of the front half of the eye, numerous deeply pigmented radial folds are seen to extend meridionally, or radially, immediately posterior to the iris, and to surround the space in which the lens was situated. These folds are the ciliary processes, whose function is to produce the aqueous humour. From this fluid which fills the aqueous chamber, the cornea, the lens and part of the vitreous humour receive their nourishment.

In antero-posterior section of the eye the ciliary body is seen to be composed of—

(1) An outer muscular portion, which contains the ciliary muscle—the muscle of accommodation. This muscle consists of two main portions (*a*) the outer or longitudinal, and (*b*) the inner or circular. In the outer part, the unstriated fibres are arranged longitudinally, and pass forwards to converge to a tendon which is inserted into the sclera with the ligamentum pectinatum at the corneo-scleral junction. The circular portion lies internally (see Fig. 90). The longitudinal fibres act by drawing the ciliary body and choroid forwards, and so relaxing the fibres of the suspensory ligament. The circular fibres perform the same function in a different manner. The relaxation of the suspensory ligament allows the lens to become more convex.

(2) An inner portion, composed of loose vascular connective tissue covered by the double layer of epithelium. This is the portion concerned with the production of the aqueous to which reference has already been made.

The *choroid* is a highly vascular membrane, usually deeply pigmented, and extends backwards from the ora serrata to the optic nerve. Externally, between it and the sclera, is the supra-choroidal lymph space, and internally a structureless membrane separating it from the retinal pigment epithelium. The numerous blood vessels are arranged in layers according to size, the largest externally and the delicate capillary network internally (see



Fig. 110). The functions of the choroid are nourishment of the retina and vitreous and insulation of the sensory coat from light by means of pigment.

*Blood Supply.*—The uvea is supplied with blood by three series of arteries: (1) the short posterior ciliary, (2) the two long posterior ciliary, and (3) the anterior ciliary. The first and second sets perforate the sclera a short distance from the optic nerve. The short arteries pass at once to the choroid and divide into numerous branches, which form the delicate capillary network of the choroid. The two long arteries pass forwards in the horizontal meridian between the choroid and the sclera. Each divides into

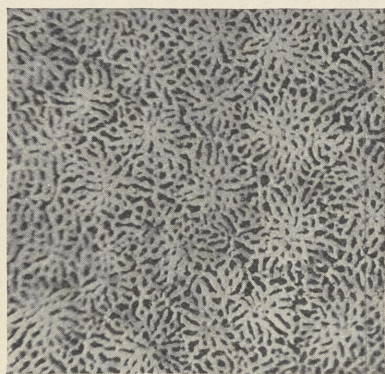


FIG. 110.—The capillary network of the choroid near the posterior pole (ox). (Priestley Smith, *Brit. Journ. Ophth.*, 1921, 405. Specimen injected by F. C. Lowe.)

two branches, which form an arterial circle by anastomosis with the corresponding branches of the opposite side. This arterial circle is situated in the anterior part of the ciliary body near the root of the iris and is known as the *greater arterial circle of the iris*. The anterior ciliary arteries reach the anterior part of the eyeball along the four rectus muscles, being branches of the muscular arteries. They pass obliquely through the sclera a short way posterior to the corneo-scleral junction and join the greater

arterial circle of the iris. They give off some branches before this, which pass backwards to join with the vascular plexus of the choroid. The greater arterial arch of the iris supplies abundant branches to the ciliary body, and sends radial branches forwards in the iris. These radial vessels form the *lesser arterial circle of the iris* near the pupil margin. Thus the short posterior ciliary arteries supply the greater part of the choroid, and the long posterior ciliary and anterior ciliary pass mainly to the ciliary body and iris. All are branches from the ophthalmic artery. The venous blood of the uveal tract returns mainly by the *venæ vorticosæ* (Fig. 111). These are four or more large venous trunks formed by the union of many choroidal veins. They perforate the sclera obliquely near the equator, usually two on the nasal and two on the temporal side, a short distance above and below the



horizontal meridian. A small portion of the blood from the iris and ciliary body returns by the anterior ciliary veins, which perforate the sclera obliquely behind the corneo-scleral junction and take the same course as the anterior ciliary arteries. There are communications between these veins, Schlemm's canal, and the conjunctival veins.

The *nerve supply* of the uveal tract (see Fig. 112) is from (1) the long ciliary nerves which convey sympathetic fibres to the dilator pupillæ, and (2) the short ciliary nerves which carry sensory fibres to the iris and ciliary body from the fifth nerve, and fibres to the ciliary muscle and constrictor pupillæ from the third



FIG. 111.—A vortex vein (ox) with most of its choroidal tributaries. (Priestley Smith, *Brit. Journ. Ophth.*, 1921, 404. Specimen injected by F. C. Lowe.)

nerve. They enter the eyeball with the short posterior ciliary arteries.

**The Pupil.**—The iris is the diaphragm of the eye. Its functions are : (1) To control the amount of light which enters the eye, and so protect the retina ; (2) to increase the depth of focus in near work. Normally the pupils are equal in size. In childhood and youth they are larger than in old age. (For method of examination, see p. 11.)

**NERVE PATHS.**—Constriction of the pupil is produced through the third cranial nerve, which supplies the sphincter pupillæ muscle and also the ciliary muscle of accommodation, and effects convergence of the eyes by the action of the two internal recti. Dilatation of the pupil is produced through the sympathetic system, partly by the dilator muscle fibres of the iris and partly by the effect of vaso-constriction in the iris. In addition to the motor nerve supply, the iris and ciliary body have a sensory nerve



supply from the fifth cranial (trigeminal) through its ophthalmic division. (See schema, Fig. 112.) The route by which impulses pass to cause constriction of the pupil when the right eye is exposed to light are: Right retina and optic nerve, both optic tracts, corpora quadrigemina, third nerve nuclei in the floor of the aqueduct of Sylvius, third nerve, ciliary ganglion, short ciliary nerves. There is a communication between the two third nerve nuclei across the floor of the aqueduct. (For details as to defects of pupil reaction, see p. 290 and Fig. 191.)

REFLEXES.—(1) *Constriction* of the pupil takes place (a) on exposure of one eye to light—*direct reaction*. At the same time constriction of the opposite pupil occurs—*consensual reaction*.

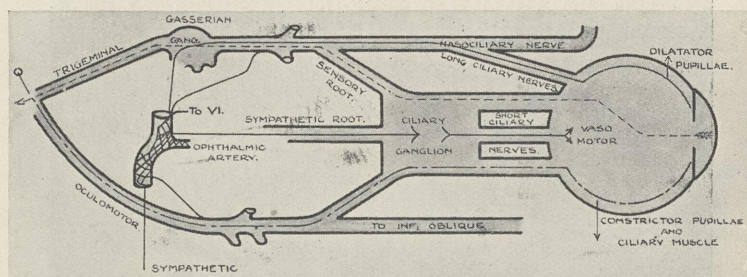


FIG. 112.—Diagram of ciliary ganglion with its connections. (After Whitnall.) The pupillo-dilator sympathetic nerve fibres are shown as a continuous line— . Sensory fibres are shown by interrupted line - - - . Nerve fibres to the constrictor pupillae and ciliary muscle are shown thus — - - .

(b) With *accommodation and convergence*, in the effort of looking at a near object.

(2) *Dilatation* of the pupil occurs (a) when the eye is shaded; (b) when the eye changes from near to distant vision; (c) with cutaneous stimulation of the neck, as by pinching the skin; (d) in emotional states, such as fear. The first two causes are the exact opposites of those in group (1).

ACTION OF DRUGS.—*Mydriatics* dilate the pupil. Atropine acts by paralysing the nerve endings of the third nerve in the sphincter pupillae and also in the ciliary muscle, and so dilates the pupil and paralyses the accommodation. Atropine, instilled into the eye as drops, is sometimes absorbed in sufficient quantity to cause poisoning. The symptoms are dryness of the throat, nausea, vomiting and, in extreme degrees, delirium. Homatropine has a similar but more transient effect. Cocaine produces pupil dilatation by stimulating the sympathetic fibres. It also has an



anæsthetic action on the conjunctiva and cornea, and by its sympathetic action blanches the eye. Used to excess, it desiccates and roughens the surface of the cornea. *Myotics* cause constriction of the pupil. *Eserine* stimulates the third nerve endings to produce this effect.

### CONGENITAL ABNORMALITIES

*Persistent pupillary membrane* is found occasionally as delicate strands of tissue which extend generally from one part of the

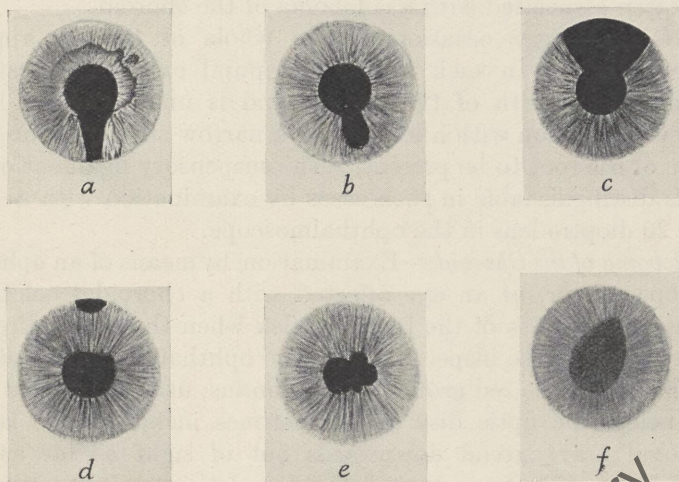


FIG. 113.—Pupil anomalies. (a) congenital coloboma of iris (see p. 154); (b) Optical iridectomy (see p. 273); (c) iridectomy for glaucoma (see p. 272); (d) peripheral iridectomy, as in trephining (see p. 268); (e) irregular pupil in iritis after application of a mydriatic, with posterior synechiæ (see p. 158); (f) Pear-shaped dilated pupil, with corneal haze, in acute glaucoma (see p. 208). (See Fig. 99, Injuries.) [Drawings by Hamblin.]

anterior surface of the iris to another and occasionally to the anterior surface of the lens. These strands should be distinguished from the bands of posterior synechiæ which pass from the pupil margin to the lens. They are normally the result of persistence of the foetal anterior vascular sheath of the lens which disappears a few weeks before birth.

*Heterochromia iridis* is said to be present when marked differences in colouration of the iris are seen. It occurs in the form of patches or spots of colour—for example, spots of brown on a blue iris—as sectors of colour, or with one iris brown and the other blue. To a slight degree it is common. It serves sometimes as



a useful means of distinction between twins. The congenital form is generally noticeable within a few months of birth (at which the eyes are blue). It must be distinguished from the acquired form, the result of iridocyclitis.

*Ectopia*<sup>1</sup> of the pupil is a rare condition of eccentricity of the pupil. The displacement is usually upwards and to the temporal side, and is symmetrical in the two eyes.

*Coloboma*<sup>2</sup> of the iris is the deficiency of a segment of the iris, so placed that the pupil is extended downwards. It may be complete, in which a complete sector is absent, or partial (see Fig. 113). It is often associated with a coloboma of the choroid.

*Aniridia*.—Very occasionally the whole of the iris appears to be absent. In such a case the pupil extends almost the whole of the width of the cornea, and is unaffected by light. Close examination with a lens shows a narrow strip or some fragments of iris root to be present. The suspensory ligament of the lens is distinguishable in such cases by examination with a + 15 or + 20 diopetre lens in the ophthalmoscope.

*Coloboma of the Choroid*.—Examination, by means of an ophthalmoscope mirror, of an eye affected with a choroidal coloboma reveals a whiteness of the fundus reflex when the eye is directed downwards. Close inspection with the ophthalmoscope discloses the absence of the red ground of the fundus, usually over an oval area below the optic disc and sometimes including the latter. The oval may extend downwards out of sight as far as the ciliary body. The appearance is due to a deficiency in the choroid. The white ground is the sclerotic, usually thinned and depressed. Its sharply defined margin is generally pigmented. Over it some retinal vessels may be traced to the optic disc, and one or more posterior ciliary vessels appear in the area. There is a loss of the visual field which corresponds with the defect.

*Coloboma of the Optic Disc*.—A crescent-shaped extension downwards of the optic disc is more commonly seen than a choroidal coloboma. It is present in association with the latter in some cases. It is due to a deficiency in the choroid immediately adjoining the disc.

*Albinism* is congenital and often inherited. The skin is very fair, and the hair, lashes and eyebrows are almost white. The retinal epithelium and the choroid partake in the general deficiency of pigment. The symptoms are photophobia and defective

<sup>1</sup> ἔκ = out of. τόπος = place.

<sup>2</sup> κολόβωμα = mutilation.



PLATE VII.

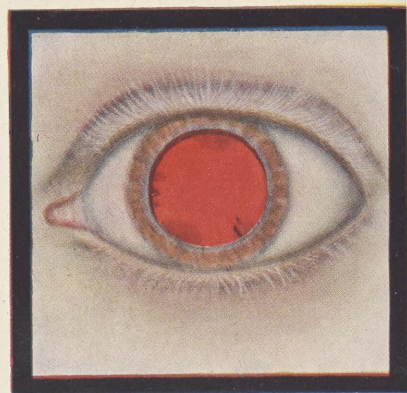
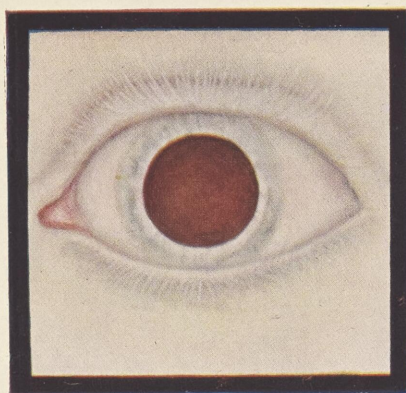


FIG. 114.—Albino. 1. Focal illumination. 2. Ophthalmoscopic.



FIG. 116.—Iritis, left eye (after use of a mydriatic). (See p. 158.)



FIG. 119.—Disseminated choroidito-retinitis. (See p. 166.)

*Drawings by Hamblin*

[To face]



vision. Nystagmus is present in marked cases. Examination of the eye by focal light reveals a dull red pupil reflex and a glimmer of red through the pale grey iris. Ophthalmoscopy produces a specially bright fundus reflex through the pupil, and a dull red through the iris stroma (see Fig. 114). The greater part of the fundus is almost white, with retinal and choroidal vessels shown up in strong contrast.

### TRAUMA (see p. 98).

### INFLAMMATION

Inflammation of the uveal tract may be divided into—

- (A) Acute suppurative.
- (B) Subacute and chronic.

(A) **Acute suppurative inflammation** of the uveal tract is exogenous or endogenous. It starts probably in one portion of the uvea and rapidly extends. Before long all the structures of the eye become affected and the condition of *panophthalmitis* is present.

**ÆTIOLOGY.**—Exogenous infection enters the eye by penetrating wounds or during operations, or through the infection of prolapsed iris or ciliary body a short time after the infliction of such wounds. Endogenous infection, in which the organism is carried by the blood stream, arises in many ways:—pyæmia or septicæmia especially puerperal, following severe compound fractures such as war wounds, or occasionally in specific fevers.

**SYMPTOMS AND SIGNS.**—Severe pain in and around the eye of rapid onset is usual in cases of penetrating wounds, with photophobia and lachrymation. Metastatic cases are often painless. The eyelids are red and swollen, the conjunctiva chemosed. There is intense conjunctival and ciliary congestion. The cornea becomes hazy, the aqueous cloudy and rapidly purulent. Sight is soon lost. Occasionally the cornea and anterior chamber remain clear till later, and pus forms first in the vitreous. If operative treatment is not adopted, the eyeball bursts near the corneo-scleral junction, and discharges pus, with the relief of pain. Eventually the eye shrinks up into a mere knob with the subsidence of the suppuration. Sympathetic ophthalmia does not follow acute suppuration.

**TREATMENT** is enucleation of the eyeball (see p. 260).\* Excision of the eye is generally regarded as dangerous, and liable to lead

\* N.B.—No glass ball should be introduced in these cases.



to meningitis by spread of inflammation from Tenon's capsule along the subdural sheath of the optic nerve.

Less acute forms of suppuration occur in which the outer or fibrous coat of the eye is comparatively little affected. In these, although considerable necrosis of the uvea may occur, resolution takes place by fibrosis. The eyeball becomes soft, shrinks and resolves itself into a condition of *atrophy* of the eyeball (see Fig. 115). Such a degree of suppuration has been called *endophthalmitis*.

(B) **Subacute and Chronic Uveitis.**—This group includes all

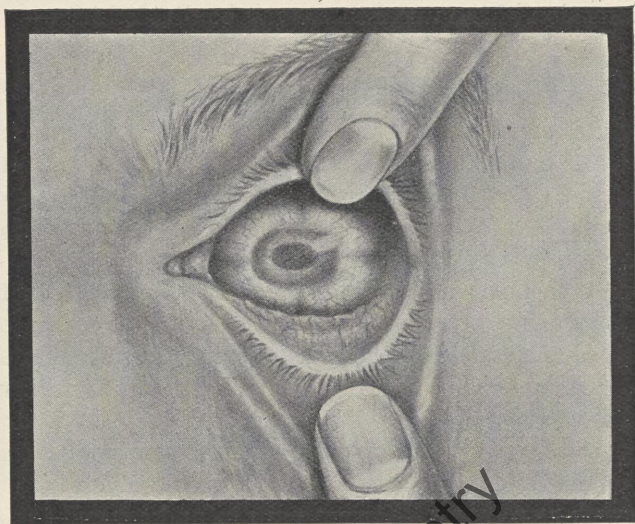


FIG. 115.—Atrophy of eyeball following severe cyclitis. Marked shrinkage of the eyeball and formation of sulci corresponding with the position of the four rectus muscles, and resulting quadrilateral shape of eyeball. [Drawing by Hamblin.]

cases of inflammation which fall short of suppuration or pus formation within the eye.

#### **Iritis, Cyclitis and Iridocyclitis.**

ÆTIOLOGY.—(a) Syphilis, congenital or acquired, (b) gonorrhœa, and (c) sepsis in other parts are the commonest causes; (d) tuberculosis is occasionally a cause, and rarely diabetes. Of syphilitic cases, those due to congenital syphilis occur in connection with interstitial keratitis. The remainder occur in the secondary stage of acquired syphilis. Gonorrhœal uveitis appears some weeks or even months or years after the onset of the urethritis, and indicates infection of the posterior urethra in the



male. It is often associated with "rheumatism," and sometimes with gonorrhœal arthritis. Cases of septic origin are mostly due to dental sepsis, a few to inflammation of tonsils, nasal cavities, gastro-intestinal tract or uterus. The following table indicates the more important divisions :—

Iritis . . . . .	{	Secondary syphilis.
	{	Gonorrhœa.
	{	Tuberculosis (rare).
Iridocyclitis . . . . .	{	Dental sepsis.
	{	Congenital syphilis.
	{	Septic (various).
	{	Tuberculosis (rare).
	{	Sympathetic.

It is probable that the causative micro-organism is carried to the iris or ciliary body by the blood stream, although proof of this is lacking in most cases.

**SYMPTOMS AND SIGNS.**—(For methods of examination, see p. 11.) In iritis and cyclitis the patient often complains of lachrymation and photophobia as the first symptoms. Pain in the eye, radiating in severe cases, is usual, but is occasionally absent in mild cyclitis. Tenderness in the ciliary region is often present. Diminution of vision occurs in both, and is sometimes the only symptom of cyclitis. A few or many of the signs may be present, and with extreme variation in their severity in different cases. They can be grouped as follows :—

**Iritis.**—*Circumcorneal or ciliary injection* is a dull red or mauve-tinted flush which occupies the area of the sclerotic immediately around the cornea. It is due to engorgement of the surface blood vessels connected with the perforating tributaries of the anterior ciliary veins. It indicates an engorgement of the deep structures drained by these veins, namely, the iris or ciliary body, especially the former.

*Haze of the cornea* in iritis is due to œdema of the substantia propria, and the production thereby of rucks or folds of the deep surface of the cornea (see Fig. 91). These folds, *deep striation of the cornea*, are seen with a magnifying glass by focal illumination as delicate grey lines, often more or less parallel.

*Small Pupil.*—The pupil is small owing to vascular engorgement of the iris and spasm of the sphincter pupillæ, and its reaction is impaired. Twenty minutes after the application of homatropine and cocaine drops to the conjunctiva, partial



dilatation reveals a festooned pupil (see Fig. 113). This is owing to the adhesion of the inflamed pupil margin of the iris to the lens at certain places. Between these adhesions, or posterior synechia, the pupil is free to dilate to a certain extent.

*The Iris.*—The colour of the iris is changed, particularly when it is of light colour. A grey or blue iris usually changes to a greenish hue. The radiating lines which form its pattern are obscured by swelling and exudate (see Fig. 116, Pl. VII., p. 155).

*Blood vessels* may be detected on its surface.

*Posterior synechia*, to which reference was made above, are best demonstrated by the instillation of homatropine and cocaine drops. The early application of a mydriatic after the onset of iritis may, by vigorous dilatation of the pupil, break down new adhesions. At the site of the adhesions, pigment spots will be found on the anterior surface of the lens. Such spots are often arranged more or less in the form of a circle, and are of importance as indicating the existence of past synechia. Repeated attacks of iritis are liable to lead to adhesion of the whole extent of the pupil margin to the lens. This condition is called *annular posterior synechia*, *seclusion of the pupil*, or *iris bombé*, and is liable to be followed by glaucoma. When a cellular exudate is deposited from the iris on to the anterior lens surface so as to occupy the whole pupil, it usually becomes organised into a membrane of fibrous tissue. This membrane obstructs the passage of rays into the eye and impairs the vision to a serious degree. The obstruction is known as *occlusion of the pupil*.

*Tubercles or nodules* are sometimes visible on the anterior surface of the iris in tuberculous or syphilitic iritis. They are of yellow or pinkish-yellow colour. They are formed of closely packed masses of inflammatory cells in the stroma of the iris.

*Exudate* in the anterior chamber arises either from the iris or ciliary body or from both structures. It is found in the most severe cases of iritis or cyclitis, and accumulates chiefly in the lower part of the anterior chamber, as a pale yellowish mass. It is comparable with the hypopyon of acute inflammations, but is more plastic and tenaceous, and less fluid. An uncommon form of exudate is produced in gonorrhœal iritis as a semi-transparent jelly-like mass. Rarely hæmorrhages occur in the most acute cases of the same infection.

**Cyclitis.** The physical sign of paramount importance in inflammation of the ciliary body is the presence of *keratic precipitates*, or "K.P." They are recognised by examination with



a magnifying lens under oblique focal illumination as grey-white dots on the deep surface of the cornea, usually in the lower quadrant (see Figs. 104 (Pl. VI., p. 140, 117). These spots, composed of aggregations of small lymphocytes, are best seen against the background of the pupil when the eye is directed upwards. If the deposits vary in size, the larger are situated below. Particularly

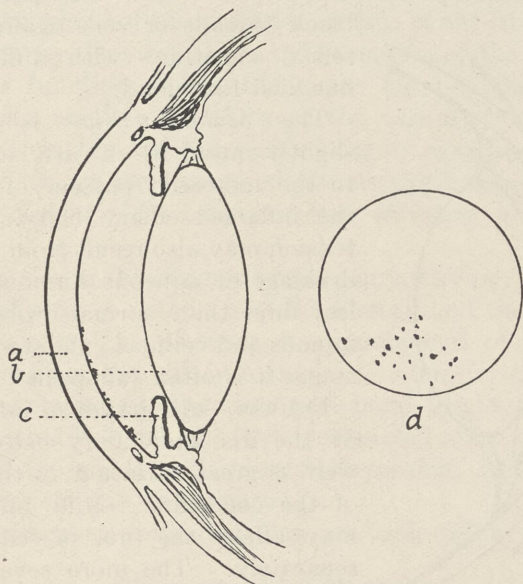


FIG. 117.—Drawing of sagittal section of cornea with deposit of "K.P." on its posterior surface compared with that of the ophthalmoscopic appearance of the same eye in life. (a) Cornea, with deposit of "K.P." (keratic precipitates) on its posterior surface; (b) lens; (c) iris; (d) ophthalmoscopic appearance of "K.P." Black spots visible in the pupillary area (see p. 110 examination of the eye).

large deposits of a whiter colour are referred to as "mutton-fat K.P." Such precipitates are more common in tuberculous cyclitis.

*Haze of the aqueous humour* can sometimes be detected by focussing upon the cornea the image of a small or narrow source of light, such as the luminous filament of a half-watt lamp, or of an ordinary electric lamp held 3 or more feet distant. A narrow beam of light is by this means projected obliquely through the aqueous. The beam of light normally traverses the aqueous without illuminating it. If there be a suspension of inflammatory cells in the aqueous, the beam of light will be visible as it passes through the fluid. It is essential to examine for the beam with the dilated pupil as a background.



*Exudate*, as already stated, may be found in the lower part of the anterior chamber in iritis or cyclitis.

*The anterior chamber is usually deeper than normal.*

*The pupil is sometimes dilated in the absence of iritis.*

*The vitreous* contains floating opacities due to cellular exudates from the ciliary body. Sometimes they are readily visible with the ophthalmoscope armed with a + 6 or + 8 D. lens, as coarse black threads or veils against the red reflex, sometimes with difficulty as a fine dust-like cloud.

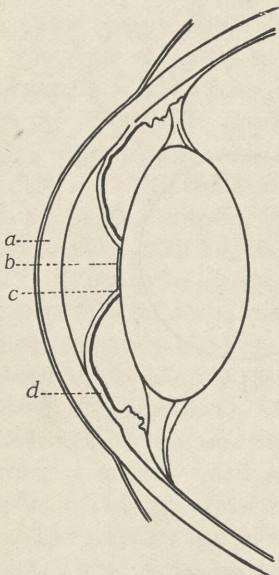


FIG. 118.—Sagittal section of anterior part of eye. Iris bombé, with peripheral anterior and pupillary posterior synechiæ. (a) Cornea; (b) pupillary membrane; (c) posterior synechia; (d) peripheral anterior synechia.

*The ocular tension* is sometimes slightly raised in an early stage, owing to the increased passage of fluid from the inflamed ciliary body. A rise in tension may also result from diminished drainage of aqueous humour, which is less fluid than normal owing to albuminous and cellular exudates. In later stages it is often subnormal.

**COURSE.**—All grades of inflammation of the iris and ciliary body occur as well as great variation in the duration of the condition. Mild inflammation may affect the iris or ciliary body separately. The more severe degrees of inflammation more often involve both structures. A mild form of iritis shows merely a slight circumcorneal flush and a pupil that is somewhat sluggish in reaction. A mild attack of cyclitis may cause the patient to complain of mistiness of vision, and careful examination reveals only a delicate deposit of keratic precipitates. A severe attack of iridocyclitis, on the other hand, causes severe pain, photophobia and lacrymation, and exhibits to a high degree all or most of the signs above described.

**COMPLICATIONS.**—*Posterior synechiæ*, by the adhesion of parts of the pupil margin to the anterior surface of the lens, prevent full dilatation. Repeated attacks of iritis lead eventually to *annular posterior synechia*. This is often associated with *occlusion of the pupil* by the organisation of exudate over the whole pupillary



area. The latter complication causes great impairment of vision; the former is liable to produce *secondary glaucoma* by obstructing the flow of aqueous from the ciliary body into the anterior chamber. With the persistence of normal formation of aqueous the iris is bellied forwards, so that it lies peripherally in contact with the cornea. This condition is called *iris bombé* (see Fig. 118). It cannot be produced when total posterior synechia is present, in which the whole of the posterior surface of the iris is adherent to the anterior lens capsule. Inflammation of the ciliary body impairs its function of nourishing the lens, so that *secondary cataract* may result. In addition, the organisation of inflammatory cells in the anterior part of the vitreous sometimes, by contraction of the newly formed fibrous tissue, drags upon and causes *detachment of the retina*, or even *shrinkage and atrophy of the eyeball*.

**DIAGNOSIS.**—In the diagnosis from conjunctivitis, the following are especially to be noted: (1) The history and the presence of *lacrymation*; (2) the presence of engorgement of a mauve or bluish-red tint in the ciliary region, *i.e.*, *ciliary or circumcorneal injection*, as opposed to the more peripheral bright red injection in conjunctivitis; and (3) the contracted state and sluggish reaction of the *pupil*, with posterior synechiæ, which are more evident after the use of a mydriatic.

For the diagnosis from glaucoma, see table below.

### Glaucoma and Iridocyclitis DIFFERENTIAL DIAGNOSIS

	CHRONIC GLAUCOMA.	ACUTE GLAUCOMA.	IRIDOCYCLITIS.
History	Premonitory transient attacks of misty vision with haloes and pain, which last a few hours and then pass off.	Premonitory transient attacks of misty vision with haloes and pain, which last a few hours and then pass off.	In any previous attacks, failure of vision, if noticeable, would have lasted <i>weeks</i> , not hours. ("K.P." and vitreous opacities.) No haloes.
Visual acuity	Very slight depression till late.	Rapid and serious failure. *Haloes and coloured rings around lights.	Loss commensurate with amount of "K.P." and vitreous floating opacities. Mistiness.

\* Haloes and coloured rings round lights may occur in conjunctivitis owing to the presence of a film of mucus or mucopus on the cornea. They are abolished by blinking or by bathing the eye.



	CHRONIC GLAUCOMA.	ACUTE GLAUCOMA.	IRIDOCYCLITIS.
Field . .	Gradual contraction of visual field.	Vision so poor that fields cannot be taken.	—
Pain . .	Slight or absent	Severe, referred chiefly to forehead and temple. (Pressure on ciliary nerves.)	In the eye, and tenderness over the ciliary region. (Absent in cases free from "ciliary congestion.")
Congestion .	Absent.	Widespread purple red congestion over sclerotic.	Ciliary (or circumcorneal) congestion.
Cornea .	Normal.	Steamy, with minute clear black superficial bullæ visible with a lens. (Edema of epithelium.)	Slight haziness occasionally, due to deep corneal striation. (Edema of substantia propria). Also "K.P."
Anterior chamber.	Shallow.	Shallow.	Normal or deep.
Exudate .	None.	None.	"K.P." on deep corneal surface. In anterior chamber. Floating vitreous opacities.
Pupil . .	Slightly enlarged, sluggish contraction badly maintained.	Dilated, oval or pear-shaped; fixed.	Small, irregular. On dilatation with mydriatic becomes festooned owing to posterior synechiæ unless annular synechia present. Brown pigment spots on anterior surface of lens.
Iris . .	Pale patches of atrophy in severe, long-standing glaucoma.	Pale patches of atrophy in severe, long-standing glaucoma.	Discoloration of iris due to vascular engorgement and exudate.
Optic disc .	Cupping.	Fundus invisible owing to corneal haze.	Normal.
Effect of treatment.	Very little, if any, improvement in vision, or return of field loss. Arrest of progress in early cases.	Considerable rapid improvement of vision.	Gradual improvement of vision concurrently with absorption of "K.P." and floating vitreous opacities.

PROGNOSIS. In mild cases without recurrences, the inflammation sometimes disappears completely with very little impairment of vision. In severe or recurrent cases the prognosis is grave. It is naturally much improved if the cause can be found and eradicated.



TREATMENT OF IRITIS AND CYCLITIS.—(1) *The cause*, if discovered, should be dealt with. Syphilis is treated by injections of novarsenobenzol or other organic arsenic preparations, and by the administration of mercury and potassium iodide. Tuberculosis requires attention to the general health and surroundings. Urethritis needs local treatment, of the posterior urethra in particular. Every effort should be made to remove any focus of sepsis in any part of the body.

(2) *General treatment* consists in the stimulation of excretion, by aperients, diaphoretics, diuretics, the imbibition of large quantities of bland fluid, and by hot-air baths. Mercury inunction, and potassium iodide or sodium salicylate by the mouth, are sometimes of use. If improvement is not obtained by other means, injections of tuberculin, gonococcal vaccine, or staphylococcal vaccine should be employed where indicated. Claims of success have been made for the application of the method of protein shock by subcutaneous or intramuscular injection of sterilised milk in from 3 to 10 c.c. doses. An injection is given every three days until no reaction is produced thereby.

(3) *Local Treatment*.—The pupil should be dilated in order to prevent the formation of posterior synechiæ. Atropine drops, or atropine with cocaine, are used, or hyoscine in cases of atropine irritation. Dark glasses are generally ordered to protect the eyes from glare. The application of dry or moist heat should be carried out as in inflammation of the cornea (see p. 126). Leeches applied to the temple help to relieve pain.

(4) *Complications*.—When complete posterior synechia has not developed, increase of tension if present can be relieved by repeated paracentesis of the anterior chamber (see p. 276). If iris bombé is present, iridectomy is necessary in order to restore communication between the anterior and posterior chambers, and to prevent the destruction of sight by glaucoma. An operation for extraction of a secondary cataract is fraught with danger, but is sometimes very successful in restoring vision when both eyes are almost blind. A painful eye that is blind, or almost devoid of vision, should be excised.

**Sympathetic Ophthalmitis** (syn. sympathetic ophthalmia, sympathetic uveitis).—In rare instances, at an interval after an eye has been wounded the second eye becomes inflamed. The inflammation affects the uveal tract, sometimes at first the choroid, at other times the iris and ciliary body. This affection of the second or uninjured eye is known as "sympathetic ophthal-



mitis." The injured eye is referred to as the *exciting eye*, the other as the *sympathising eye*.

ÆTIOLOGY.—The injury is usually one in which either the iris or ciliary body is prolapsed into the wound, and exposed to infection from the conjunctival sac. Especially dangerous are wounds in the ciliary region, as the difficulty of preventing prolapse is here much greater. Accidental penetrating wounds, wounds with retention of a foreign body—a fragment of metal or a chip of stone, occasionally the operation wounds of cataract extraction are responsible. The most probable route by which infection is carried to the sympathising eye is the blood stream. The infection may apparently remain dormant for a time, or at least begin so insidiously as not to be detected for some weeks. This is shown by the fact that signs of sympathetic ophthalmitis may appear in the second eye some days after the excision of the exciting eye as been performed.

SYMPTOMS, SIGNS AND COURSE.—The symptoms and signs are usually those of iridocyclitis, which starts insidiously and has exacerbations with periods of comparative quietude. Other cases progress steadily to a condition of very severe inflammation with much pain, with exudate in the anterior chamber and in the pupil.

Inflammatory exudate is formed around the equator of the lens and in the vitreous. With the subsidence of the acute stage organisation of the exudate takes place, and contraction of the newly formed fibrous tissue, so that the tension falls. The eyeball becomes quite flaccid and gradually shrinks. The condition of atrophy of the globe is thus established. Sometimes the disease begins in the choroid, with dimness of vision, the result of infiltration in the choroid and exudate in the vitreous. Iridocyclitis develops later, and the course of the disease is similar to that described above.

PROGNOSIS.—In the majority of cases loss of vision and complete atrophy of the eyeball take place in the sympathising eye. In the exciting eye, on the other hand, a moderate amount of vision sometimes remains.

TREATMENT.—When once the disease is fully established it is inadvisable to excise the exciting eye, for the reason just stated. Treatment of the iridocyclitis is as for other forms already described, with the addition of injections of novarsenobenzol. Sympathetic ophthalmitis can be prevented by the early removal of an injured eye (1) in which the damage is severe ; (2) in which



uveal tissue is prolapsed and the prolapsed tissue cannot be removed or completely covered by conjunctiva; (3) in which lacrymation and circumcorneal injection remain for fourteen days without definite signs of improvement; (4) into which a foreign body has penetrated, and from which this cannot be removed. (For the treatment of penetrating injuries, see p. 101.)

**Choroiditis.**—(1) Acute suppurative (see Panophthalmitis); (2) subacute or chronic.

Choroiditis is described as *central* or *peripheral*, according to its position, and as *localised* or *disseminated*.

**ÆTIOLOGY.**—The commonest cause of choroiditis is syphilis—congenital more frequently than acquired. In both of these it is usually of the disseminated type. A localised patch of choroiditis is less common, and is usually due to a septic focus elsewhere—in connection with the teeth, or in the nose or throat especially. Rarely a solitary patch may be of tuberculous origin. One or more miliary tubercles are occasionally seen in the choroid in general or meningeal tuberculosis in children. Central or macular choroiditis is usually a senile change.

**PATHOLOGY. SYMPTOMS AND SIGNS.**—Congenital syphilitic disseminated choroiditis occurs in infancy, or soon after, and is discovered by ophthalmoscopic examination in later years. It is generally bilateral. Patients affected with choroiditis in later years complain of floating spots before the eyes, or of mistiness of vision in the affected eye, owing to the presence of exudate in the vitreous. If the choroiditis occurs in the macular area vision is seriously damaged. Disseminated choroiditis in acquired syphilis is usually unilateral. The term “choroiditis” is often used to denote the permanent condition present long after the subsidence of active inflammation. In the active stage, whether the disease be localised or disseminated, the pathological change consists in the infiltration of the choroid with inflammatory cells. The infiltration takes the form of solitary—usually larger—or multiple smaller, discrete or confluent nodules. Clinically, nodules seen with the ophthalmoscope in the active stage appear as pale yellow patches with an ill-defined border, and without any visible retinal vessels passing over them. In disseminated choroiditis the patches, where they are visible discretely, have generally a smaller diameter than that of the optic disc. A solitary patch is usually about the size of the disc or larger. In the process of inflammation the structure of the choroid is largely destroyed, and the overlying retina damaged. With



subsidence of the inflammation the nodule or nodules of inflammatory cells give place to newly formed fibrous tissue. In place, therefore, of normal vascular choroid and retina is a sheet of fibrous tissue with mere remnants of these structures at the site of the inflammation. Around the affected area the retinal pigment epithelium proliferates and forms an irregular ring of dense pigment. Ophthalmoscopically, therefore, the pale yellow patch of active inflammation is replaced by a dead white patch with an irregular, deeply pigmented margin. A few choroidal vessels are usually visible on the white patches (see Fig. 119, p. 155). Corresponding with these white patches of atrophy of the choroid there are defects, or scotomata, in the field of vision. These scotomata are usually *negative scotomata* (see p. 18). When the damage occurs in the macular area the interference with vision is much more serious.

DIAGNOSIS.—In the *active* stage the diagnosis of choroiditis is made on (1) the history of mistiness of vision or floating spots; (2) the presence of floating threads or particles, or dust-like opacities in the vitreous; (3) the pale pinkish-yellow or yellowish spots or masses in the choroid. *Old or obsolete* choroiditis is to be distinguished from retinitis pigmentosa (see p. 195), in which there is usually a marked pigmentation in the fundus of the eye, with some pallor between the pigmented patches, owing to choroidal vascular sclerosis. In both there is often night blindness owing to the extent of atrophy of the peripheral retina. Careful examination with the ophthalmoscope will usually reveal some discrete rounded white patches with a pigmented margin in cases of choroiditis. These patches indicate destruction of the choroid at the site of past inflammation.

TREATMENT.—If the diagnosis is made when the disease is in the active stage, a thorough investigation should be made in order to find the cause, and the appropriate treatment should be adopted (see *Iridocyclitis*, p. 163). The eye itself should be protected by dark glasses or an eyeshade, and close work should be avoided. In the uncommon case of tuberculosis, if the disease is protracted and does not improve with tuberculin treatment, if swelling of the choroid increases extensively, or if the vision is almost destroyed, the eye should be removed.

TAY'S CHOROIDITIS (syn. guttate choroiditis).—In elderly people the macular region is sometimes found to be studded with small, rounded, pale yellowish spots. There is commonly little or no impairment of vision. The spots are due to excrescences of



colloidal material on the surface of the choroid. They represent a degenerative change, and not an inflammation of the choroid.

CENTRAL OR MACULAR CHOROIDITIS is another change in the same region, and is either a senile degenerative phenomenon or the result of a mild inflammation secondary to a septic focus elsewhere. It is characterised by a mottled appearance, due partly to loss of red colour from atrophy of choroidal vessels and partly to pigment proliferation.

MYOPIC ATROPHY.—In high degrees of myopia certain changes take place to the temporal side of the disc and in the macular region which may sometimes be confused with the appearances of past choroiditis. This should be borne in mind during the examination of highly myopic eyes (see *Myopia*, p. 50).

## NEOPLASMS

The uveal tract is rarely the subject of new growths.

**Simple new growths** are cysts and melanomata. A melanoma of the iris is visible as a pigmented nodule slightly raised above the surface. Provided that it does not enlarge, it requires no treatment. If it increases in size, it should be removed by iridectomy. A melanoma of the ciliary body is usually found during pathological examination. Melanomata of the choroid are occasionally seen in ophthalmoscopic examination of the fundus of the eye.

**Malignant New Growths.**—Malignant neoplasms of the uveal tract are rare. They occur in the form of (1) a primary sarcoma, or (2) a secondary or metastatic carcinoma, the latter being extremely uncommon.

1. **Primary sarcoma** of the uveal tract is found in the choroid in the majority of cases. Much less frequently it affects the ciliary body, and still less the iris. It is usually detected between the ages of forty and sixty years.

**SYMPTOMS AND SIGNS.**—The presence of a sarcoma in the choroid may make itself felt merely by slight impairment of vision. The degree of impairment depends on the situation of the growth. If it is at or near the macula, it is noticed sooner than if it is at the periphery. (2) Pain due to acute glaucoma (see p. 214) is sometimes the first signal. (3) The presence of an epibulbar growth, either near the margin of the cornea or at the equator of the eye, may be due to an extension of an intraocular



growth. Such an epibulbar growth is pigmented, non-pigmented or piebald. If due to extension of a sarcoma it increases rapidly in size.

A sarcoma of the ciliary body in an early stage is invisible. Later, by extension behind the iris towards the pupil, it may be visible, when the pupil is fully dilated, as a dark-brown or black rounded mass. Sometimes it extends through the root of the iris and is visible in the periphery of the anterior chamber. In these circumstances it causes the D-shaped irregularity of the pupil typical of iridodialysis. The rare sarcoma of the iris is visible in an early stage.

**PATHOLOGY.**—In the majority sarcoma of the uveal tract is a pigmented growth, and is known as a *melanotic sarcoma*. The rarer non-pigmented variety is called a *leuco-sarcoma*. The division is arbitrary, as small collections of pigment cells are commonly to be found in a white growth on histological examination. The usual cell structure is that of a spindle-celled sarcoma. Sometimes the cells are of the "small round" variety, in which case the growth is more malignant. In deeply pigmented growths this cell structure is only visible in bleached sections, owing to the abundance of pigment granules in the cells.

**COURSE AND COMPLICATIONS.**—A sarcoma in the choroid, by extension, mainly inwards into the cavity of the eyeball, causes early *detachment of the retina*. By pressure on the vitreous or direct contact with the lens or iris, the angle of the anterior chamber is partly closed, and *glaucoma* results. *Extension of the growth* through any of the passages in the sclerotic for perforating vessels leads to its extraocular appearance. Such an extension may be visible near the cornea as a rounded mass. It is occasionally seen by extension forwards from the equator, when the eye is fully rotated. Growth at the back of the eyeball, which has spread along the tracks of the posterior perforating vessels, makes its presence suspected by causing proptosis. Finally, *metastasis* by the blood stream leads to the formation of secondary growths in the liver or lungs.

**PROGNOSIS.**—The prognosis is very grave. Even when early enucleation of the eyeball has been performed, there is no certainty that recurrence will not take place, either locally or, more commonly, by metastasis.

**TREATMENT.**—Enucleation of the eyeball should be carried out as soon as the diagnosis of intraocular sarcoma has been made. The optic nerve should be divided as far back as possible.



If the growth has extended out through the sclerotic, exenteration of the orbit is necessary.

DIAGNOSIS.—In a matter of such grave import as the removal of an eye, especially if the vision remains good, it is only prudent that two expert opinions should be obtained. The diagnosis of a melanotic sarcoma is made on the following points :—

(1) *Detachment of the retina* with a “solid” appearance, or in which the retina is raised, with a somewhat smooth surface, and in which folds do not float about from side to side as the eye moves. Especially significant is the presence of a “solid” detachment above and a “floating” detachment below, the latter being due to the action of gravity upon fluid exuded outside the retina.

(2) *A dark-brown or black colour* within the area of retinal detachment.

(3) The presence of new vessels which belong to the new growth and are deep to the retinal vessels.

(4) *Hæmorrhages* in the area of retinal detachment.

(5) The presence of a shadow or dark area within the eye on *transillumination*.

2. **A metastatic carcinoma** may resemble a primary sarcoma very closely. The history of the presence of a growth elsewhere, especially in the breast, should be investigated. The enucleation of the affected eye is occasionally necessary on account of pain. The prognosis is naturally hopeless.



## CHAPTER VIII

### THE LENS

#### ANATOMY

THE transparent *crystalline lens* is suspended centrally immediately behind the iris. It has a slightly convex anterior surface, a more deeply convex posterior surface, and a rounded peripheral border—the *equator*. To the peripheral parts of its anterior and posterior surfaces the fibres of the suspensory ligament are attached. These anterior and posterior fibres intersect and pass to their insertion into the ciliary body, (1) in the grooves between the ciliary processes and (2) to the flat part of the ciliary body (*pars plana ciliaris*)(*vide* Frontispiece). The anterior surface of the lens, bathed by aqueous humour, forms the posterior wall of the posterior chamber, and its central part occupies the pupil. The pupillary border of the iris is lightly in contact with it. When the lens is dislocated backwards, the iris is found to be tremulous owing to the absence of the steadying effect of the lens behind it. The posterior surface of the lens is bedded into and supported by the jelly-like vitreous humour. The lens is enveloped by an elastic capsule, known as the anterior capsule, in front, and the posterior capsule behind. Beneath the anterior capsule is a continuous single layer of lens epithelial cells. The substance of the lens is composed of innumerable lens fibres arranged in layers more or less concentrically, after the manner of the layers of an onion. Its central portion is known as the *nucleus* of the lens. The lens substance outside this is the *cortex*.

The nourishment of the lens is provided by the aqueous humour derived from the ciliary body. The lens continues to grow throughout life, by the proliferation of the outermost cells of the epithelial layer. These new cells gradually become elongated to form new lens fibres.

By contraction of the ciliary muscle the lens is enabled to become more convex. This is known as the function of accommodation. In the state of relaxation of the accommodation, the taut fibres of the suspensory ligament maintain tension on the periphery of the lens so as to keep it somewhat flattened antero



posteriorly. Contraction of the ciliary muscle takes place with the effort of accommodation. With this contraction the inner or deep surface of the ciliary body is made to protrude slightly, and at the same time the anterior part of the choroid is believed to be drawn slightly forwards. This protrusion takes place into the cavity of the eyeball and towards the equator of the lens. The effect of this inward protrusion is the relaxation of the fibres of the suspensory ligament of the lens. The latter is thereby permitted to return somewhat towards its embryonic globular shape. There is relatively a greater thickness of the peripheral parts of the anterior elastic capsule as compared with its centre. During accommodation, therefore, the weaker central portion of the anterior capsule allows the lens to bulge and become more convex in the central part of its anterior surface. At this site the major part of the increase in convexity of the lens during accommodation is effected. Throughout life the nucleus of the lens undergoes a process of sclerosis or hardening. With this change the elasticity, and therefore the accommodation power, are diminished. Presbyopia or "age sight" is thus produced.

Apart from displacement or subluxation, there is one pathological condition to which the lens is subject. It embraces the vast majority of cases in which defective vision is due to some anomaly of the lens. This condition is cataract, or opacity in the lens. It is convenient to classify the affections of the lens in the same manner as has been adopted for other structures of the eye. It enables a rapid review to be made of the various causes of cataract. The following terms should be noted. A *hard* cataract is one in which the central part of an opaque lens is not soluble in the aqueous humour. It is the condition in senile cataracts. A *soft* cataract is soluble in the aqueous humour. Upon this fact depends the treatment of cataracts—in old people by extraction of the opaque lens, and in young patients by discission or needling. The sites of polar, lamellar and nuclear cataracts are indicated in Fig. 120. The majority of cataracts concern the substance of the lens external to the nucleus—namely, the cortex. These are known, owing to their site, as *cortical cataracts*. A lens containing a cortical cataract which is *mature* or *ripe* is opaque throughout from nucleus to capsule. An immature cataract is one in which there is a variable amount of cortical substance which is still transparent. The method for testing for this is given below. (For methods of examination, see p. 177.) A *stationary cataract* is one in which the opacity does not alter



in extent or intensity with the passage of time. The commonest example of this is a congenital or infantile lamellar cataract. A *progressive cataract* increases both in extent and in density. A senile cataract is the typical example. The commonest types of cataract encountered among the ordinary population are senile cataracts in elderly people, and lamellar cataracts in children. These, therefore, will be dealt with more fully than other varieties. In industrial centres, traumatic cataracts and ironworkers' or glassblowers' cataracts are not uncommon. The latter condition is probably due mainly to the prolonged action upon the lens or ciliary body of heat rays from furnaces.

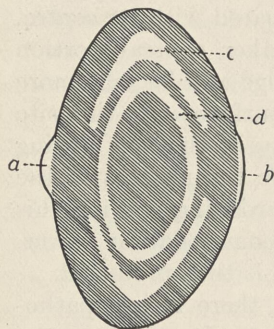


FIG. 120.—Sagittal section of lens showing position of various cataracts. (a) Anterior polar cataract; (b) posterior polar cataract; (c) early senile cataract in most cases; (d) lamellar cataract. Nuclear cataract affects the central portion of the area enclosed by (d). This area comprises the foetal nucleus.

### CONGENITAL

Congenital abnormalities of the lens are rare. CONGENITAL SUBLUXATION or displacement of the lens is usually present in both eyes. It is a familial complaint. The displacement is generally upwards. Myopia is often present and the vision is defective. The displacement is usually found in examination of the eyes on account of defective vision. Unless the pupils are very small, the equator of the lens may often be seen on examination with focal illumination. The condition is readily recognised when the pupil is dilated.

By oblique focal illumination the convex lower margin of the lens appears grey on a black ground. By reflected light from the ophthalmoscope, the convexity of the lens is semi-opaque in front of the red colour of the fundus reflex. Vision may be improved by suitable glasses. (Cf. Trauma, p. 95.)

A CONGENITAL CATARACT occurs as an anterior polar, lamellar, nuclear, or posterior polar opacity. All these forms are rare. (For sites, see Fig. 120.) A lamellar cataract of exactly similar type also develops in infancy (see p. 173). An anterior polar cataract sometimes results from corneal ulceration in infancy in ophthalmia neonatorum, and anterior and posterior stellate opacities arise in trauma. Inflammation within the eye may produce a posterior cortical cataract, starting in the most posterior layers of the cortex. The differential diagnosis depends largely



upon an investigation of the history of a case of cataract. For a discussion of the causes of congenital cataracts and information as to other still rarer varieties, reference should be made to a larger work on ophthalmology.

### TRAUMATIC AFFECTIONS

For SUBLUXATION of the lens, DISLOCATION into the vitreous chamber, the anterior chamber, or subconjunctival dislocation, TRAUMATIC CATARACT, see p. 95.

### CATARACT RESULTING FROM INFLAMMATION, OR FROM CHANGES IN THE LOCAL OR GENERAL CIRCULATION.

This group includes those cases of cataract which result from ocular disease and are known as *complicated* or *secondary cataracts*.<sup>1</sup>

**ÆTIOLOGY.**—(1) *Iridocyclitis* or *choroiditis* are forms of inflammation within the eye which are sometimes followed by the development of a cataract. Other intraocular diseases of more obscure ætiology are found less commonly as a cause. They are myopia, retinitis pigmentosa, and detachment of the retina. A cataract complicated by any of the above conditions frequently starts as a *posterior cortical cataract* in the layers immediately in front of the posterior capsule.

(2) *Glaucoma*, by its interference with the circulation of the aqueous humour, and by the damage it causes to the ciliary body, is not infrequently the precursor of cataract.

(3) *Circulating toxins* are the probable cause of cataract in a proportion of cases of *diabetes*. Such toxins may have their effect directly upon the lens, or upon the ciliary body which is the chief source of nourishment of the lens. *Lamellar* cataract in infants is also probably the result of a toxæmia which affects at the same time the developing enamel organ of the permanent incisor teeth.

**Lamellar Cataract.**—**DEFINITION.**—A lamellar (syn. zonular) cataract is an opacity situated in a layer or layers between the clear lens nucleus and the cortex. It is present at a corresponding depth both in front of and behind the nucleus which it encloses.

<sup>1</sup> The term *complicated cataract* is used on the Continent for these cases, and the term *secondary cataract* is reserved for those in which a dense membrane is formed after the operation of extraction. To avoid confusion, the term *after-cataract* is employed below to denote the condition which follows operation and of which the treatment is usually discission or needling.



**ÆTIOLOGY.**—A lamellar cataract which is developed *in utero* is probably of similar origin to one formed in infancy. In each a toxæmia is believed to be the cause, which affects at the same time the developing permanent incisor teeth. There is defective development of the enamel, which is eroded near the cutting edge, with the formation of horizontal ridges.

**SYMPTOMS AND PHYSICAL SIGNS.**—There is usually no noticeable defect until the child is several years old, unless the cataract is of unusual density. It is sometimes noticed that the child fails to see small objects. Nothing may be detected until the vision is tested, when this is found to be defective. The visual defect varies with the density of the cataract, and is sometimes

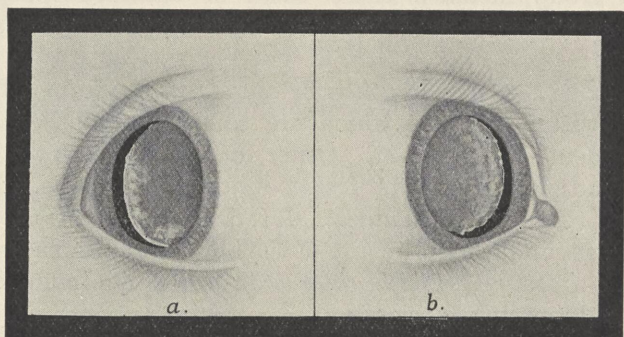


FIG. 121A.—Lamellar cataract (pupil dilated), right eye. (a) with the eye looking towards the right. The opaque portion of the lens appears to have moved to the left relative to the pupil margin. (b) With the eye looking to the left. The opacity appears to have moved to the right.

so slight that a cataract escapes detection until adult life. Both eyes are usually affected. The cataract is seen by oblique focal illumination when the pupil is dilated, as a grey disc more or less occupying the pupil. Peripheral to the cataract the pupil is perfectly clear and black, except for a few lighter grey *riders* or projections from its equator. These riders project from the equator of the cataract in a manner somewhat similar to the spokes of the steering wheel of a steamship. In actual fact they are V-shaped and ride on the periphery of the cataract, one limb passing in front and the other behind. They are opacities affecting layers of the lens superficial to the lamellæ mainly concerned (see Figs. 121A and 121B, Plate VIII., p. 176). By slight movements of his head during examination with a magnifying lens, the observer may note parallax between lines or dots of



opacity in the anterior part and those in the posterior part of the cataract. By ophthalmoscopic examination, a lamellar cataract is seen as a dark disc surrounded by a ring of red fundus reflex. The peripheral part of the opacity is apparently darker than the centre, through which there is almost always a dull red glimmer.

INDICATIONS FOR OPERATION upon a lamellar cataract.—If the vision is less than  $\frac{6}{18}$  in each eye, an operation should be performed on one eye at a time. In children and up to the age of twenty-five years needling (discission), or optical iridectomy, is carried out (see p. 271). This should be done at as early an age as possible, in order to avoid defective vision from disuse. It is usually a stationary cataract. In rare instances, in which it develops into a complete cataract, it should be treated by extraction if detected after the age of thirty years (see p. 262). Previous to this age discission is the preferable operation. In small opaque cataracts optical iridectomy is preferable (see p. 273).

### DEGENERATION

**Senile Cataract.**—Although the majority of cataracts are due to degenerative changes in the lens, senile cataract is one in which age—the period of degeneration—seems to be the dominating factor. Occasionally a similar type of cataract develops, indeed, in persons of young adult or middle age, but this is the exception. In general, a diabetic cataract is indistinguishable from a senile cataract, except that the former is sometimes of unusually rapid development. As elderly people are particularly prone to slight degrees of glycosuria, it is probable that many a cataract which develops in an elderly glycosuric patient may have no connection with this condition, but may be a simple senile cataract.

SYMPTOMS.—The subject of a mild degree of cataract formation complains usually of seeing dark spots, lines or shadows, and may have monocular diplopia or even polyopia. These marks or shadows appear fixed, that is to say they remain stationary when the eye is kept at rest. Gradually there is progressive diminution of visual acuity so that people's faces are not recognised at a distance. In some cases there is a progressive myopia, so that although distant vision deteriorates there may be for a time no interference with reading. In cases in which the lens opacity affects chiefly the centre of the lens, there is a complaint of dazzling and mistiness, especially in bright light.

PHYSICAL SIGNS AND COURSE.—(Method of examination, p. 20.)

(a) *Incipient Cataract.*—In more than nine-tenths of cases of



senile cataract the opacification of the lens starts in the peripheral parts of the cortex near the equator of the lens. Examination by oblique focal illumination reveals grey-white radiating lines (see Fig. 122A, Plate VIII.) which are thicker towards the periphery. These are seen dimly against the black background of an undilated pupil. For satisfactory examination, the use of a mydriatic is essential. Several applications of cocaine drops at

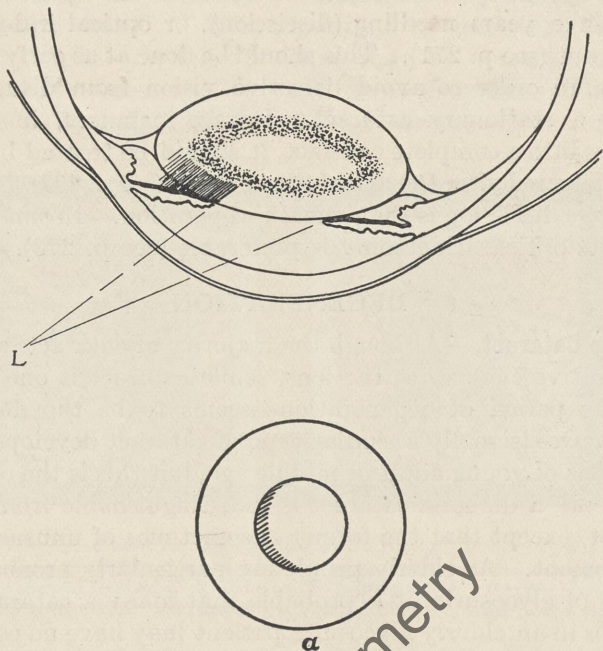


FIG. 122B.—Immature cataract (diagrammatic). Horizontal section of eye to show the method of production of a shadow in an immature cataract. L, Source of light. The stippled zone of the lens represents the opaque deeper portion of the cortex; (a) indicates the crescentic shadow cast by the iris in focal illumination on to the opaque part of the lens.

five-minute intervals often suffice, or homatropine may be necessary. Ophthalmoscopic examination through the dilated pupil shows the opacities as dark lines against the red reflex of the fundus oculi. In the small proportion, less than one-tenth of the total, in which a senile cataract starts in the central part of the lens, enveloping the nucleus, oblique focal illumination reveals a grey-white ill-defined opacity in the centre of the pupil. Movement of the eyeball suffices to determine that the opacity is situated within and not on the anterior surface of the lens (see



PLATE VIII.



FIG. 139.—Glaucomatous disc. Note bluish-white pallor, markings of lamina cribrosa and cupping, also "halo" round margin of disc. (See p. 209.)

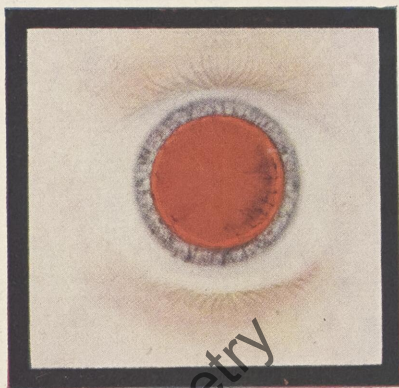
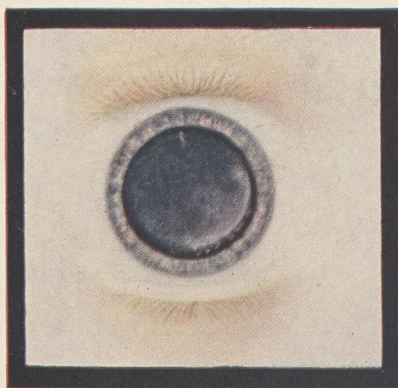


FIG. 121B.—Lamellar cataract. (See p. 173.)

1. Focal illumination.
2. Ophthalmoscopic.

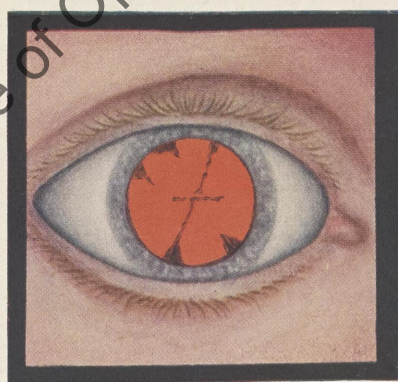


FIG. 122A.—Early senile cataract.

1. Focal illumination.
2. Ophthalmoscopic.

*Drawings by Hamblin.*

[To face p. 176.]



Fig. 16). Ophthalmoscopic examination displays a central black area with ill-defined outline in the centre of the red reflex.

The rate of progress of cataracts varies to an enormous extent. A considerable proportion of the elderly population suffers to a slight degree from the presence of cataract in the incipient stage. In only a small percentage of these is the advance of the condition sufficient to cause serious disability. In the latter the lines of opacity multiply and coalesce, to meet in the central parts of the cortex in front of and behind the lens nucleus. In this state the cataract completely obscures the red reflex and the vision is reduced to perception of hand movements or perception of light. Under oblique focal illumination, when the observer's eye is directly in front of the cataractous eye, the pupil appears bluish-white throughout, except on the side nearest the source of light. Here a crescent-shaped shadow is cast by the iris on to the opaque deeper parts of the lens (see Fig. 122B). This shadow indicates the presence of transparency in the superficial layers of the lens cortex. A cataract in this stage of development is called an *immature cataract*.

(b) *Mature Cataract*.—A cataract is said to be mature or ripe when the opacity involves the whole of the cortex of the lens. In this condition there is no transparent layer of cortex in front of the opacity and, therefore, in oblique focal illumination no shadow is cast by the iris. The whole pupil is then dull grey or amber-coloured. It is in this state that the cataract is removed or extracted most satisfactorily by operation, for the whole of the opaque lens is delivered through the rent in its capsule. In the immature state only the opaque portions of the cortex are delivered in one piece. The transparent surface layers are soft and tenacious, and cannot be removed entirely. Too long a delay before the performance of the operation is not desirable, otherwise the cataract may reach a condition of *hypermaturity*, when it is known as a Morgagnian cataract. The opaque cortex gradually becomes liquefied and of a milky colour and consistency, so that the unaltered or dark-coloured nucleus sinks down into the lowest part of the lens capsule. In the state of hypermaturity, the operation of extraction of the cataract is more difficult to perform.

**PATHOLOGY.**—The normal transparent lens is composed of a great number of layers of microscopic lens fibres. In senile degeneration, the lens fibres shrink, and become separated by fluid. Later the lens fibres become broken up into fragments. These



changes are accompanied by such alterations in refraction that much of the light which enters the pupil is reflected, so that the lens appears to be white or grey-white, and in some cases yellowish. The latter colour is due to the formation of a pigmented substance from the tyrosin, which is one of the products of degeneration. In long-standing cataracts and particularly in old traumatic and complicated or secondary cataracts, the degenerative changes are accompanied by the production of chalky deposits. In such cases the cataract is particularly white.

DIAGNOSIS.—The diagnosis of a cataract is made on (i.) the presence of an opacity in the lens, visible usually as a grey-white mass or as lines or marks in oblique focal illumination, and (ii.) interference with the red fundus reflex in ophthalmoscopic examination. A rare occurrence is a *black cataract*, by which the red reflex is abolished without the obvious presence of any opacity in focal illumination. Direct evidence may only be obtained by the use of an especially strong beam of focal light.

The determination of the type of cataract depends upon (i.) the history of the case (congenital, trauma, ocular inflammation, diabetes); (ii.) the age and general health of the patient (diabetes); (iii.) the exact site and form of the lens opacity; and (iv.) the presence or absence of other ocular disease. In order from the front to the back of the lens, the sites of various cataracts are as shown in the table on p. 179.

INDICATIONS FOR OPERATION UPON A SENILE CATARACT.—Before a decision can be made that a cataract should be extracted the following investigations should be carried out to determine:—

- (i.) Visual defect.
- (ii.) Ocular health.
- (iii.) General health.

(i.) *Visual Defect*.—When both eyes are affected with cataract one is usually found to be in a more advanced state than the other. The more advanced cataract should not be removed until it is mature (see p. 176), unless the vision of the other eye is so defective as completely to incapacitate the patient. Operation upon an immature cataract is not so satisfactory, owing to the fact that the unripe or non-cataractous superficial layers of the lens cortex are not completely evacuated. They remain between the anterior and the posterior lens capsule, become opaque and may produce a dense *after-cataract*. In addition, the lens remnants are liable to set up troublesome inflammation of the iris and ciliary body. The vision is generally reduced to perception of shadows or



NAME OF CATARACT.	SITE.	GROUP IN CLASSIFICATION.	AGE OF ONSET.	HISTORY, CHARACTERISTICS, ETC.
Anterior polar (See Fig. 120)	Lens capsule.	Congenital . Inflammatory .	Before birth . Infancy .	From birth; central white spot. From perforated corneal ulcer in ophthalmia neonatorum. Central white spot or projection (pyramidal cataract).
Anterior cortical.	Superficial layers of cortex	Traumatic .	Any age .	Follows a blow on the eye. Often stellate in form. May disappear or spread to complete cataract.
Cortical, diabetic.	Whole cortex	Circulating toxin. (Diabetes)	Mostly elderly {	Start usually in equatorial region. Progressive, from incipient to mature cataract.
Cortical, senile (See Fig. 120)	Whole cortex	Degenerative .	Senile usually.	
Lamellar . (See Fig. 120)	Layers of cortex enclosing nucleus of lens. Nucleus also sometimes.	Congenital . Circulating toxin .	Before birth . Infancy .	Usually stationary. Variable density. Riders.
Nuclear .	Nucleus	Congenital .	Before birth .	Stationary.
Posterior cortical.	Superficial layers of cortex	{ a. Traumatic . b. Inflammatory	Any age . Any age .	As in anterior cortical; often stellate. Complicated, or secondary, cataract especially in irido-cyclitis. Involves a large area at the back of the lens. Both of these may extend to become a complete cataract.
Posterior polar .	On the posterior surface of the posterior lens capsule.	Congenital .	Before birth .	Commonly a small discrete spot. Represents a remnant of the hyaloid artery.



perception of light before a cataract is fully mature. During the period of failing vision before either eye undergoes operation, much can usually be done to help the patient (see Treatment). In the case of a mature monocular cataract or one in which there is practically no visual defect in the second eye, an operation may be performed for cosmetic reasons, or to increase the field of vision on the affected side, or to prevent the development of hypermaturity. For the last reason, it is well for a patient who wishes to travel far or to remote places, to have a monocular cataract removed if it be reasonably near to maturity. The eye which undergoes operation in such a case will not work with the other, even when provided with a lens, as the size of the image on the retina will be very different in the two eyes.

(ii.) *Ocular Health*.—In every patient in whom there is an incipient cataract careful examination should be made and the result noted for future reference as to the condition of the fundus oculi in each eye. At a later period when the cataract has advanced no view of the fundus of either eye may be obtainable. When a cataract is mature, the health of the retina can only be presumed to be satisfactory (a) if, at least, perception of light be present; (b) if light projection be good (see p. 14). These two tests indicate that there is some retinal function, and that there is no gross loss of field as by detachment of retina. (c) A third test<sup>1</sup> is of use in testing the health of the macula. Black discs containing one, two or three pinholes respectively are placed directly in front of the pupil successively. A frosted electric lamp is placed close to the disc so as to illuminate the pinholes. The patient should be able to state the number of holes in each disc and their relative positions if the macula is healthy. In the rare case of a black cataract, the perception and projection of light may be uncertain.

If the above functional examination of the *retina* prove satisfactory, the health of the eye and its surroundings must be proved before it is decided to operate. The *eyelids and conjunctiva* should be free from inflammation. A bacteriological examination is usually made of a swab from the conjunctival sac. The *lacrymal sac* is tested for regurgitation. The *cornea*, the *iris* and the *pupil* are examined for signs of active or old iritis or cyclitis. The *tension* should be normal. In the case of monocular cataract, inquiry should be made for the history of any *injury*. The above-mentioned investigation will prove whether the cataract

<sup>1</sup> *Brit. Jl. Oph.*, vii., 1923.



is primary or secondary. The presence of signs suggesting that a cataract is secondary do not absolutely contra-indicate operation. In many patients so affected, a new lease of life has been given by operation. The prognosis, however, is much more grave, as the risks of operation are greater, and the health of the retina less likely to be good.

(iii.) *General Health.*—The presence of nephritis and of diabetes should be excluded. In the latter, skilled medical treatment will in most cases render the patient sufficiently well to undergo operation with a reasonable prospect of success. It should be remembered, however, that a patient the subject of diabetes is liable to diabetic retinitis.

*TREATMENT OF CATARACT.*—During the time in which the vision is seriously affected, but before a cataract is mature, much may be done to assist the patient, provided that both eyes are not equally affected. Gradual increase may be made in the strength of the reading glasses for the better eye, and the patient may be encouraged to accustom himself to reading in order to occupy his time if his distant vision become very defective. With special types of convex lens, in which spherical aberration is reduced to a minimum, it is usually possible to provide greater facility in reading by means of a high-power spectacle lens rather than with the help of a hand magnifying glass. So strong a lens may finally be required that it is necessary to hold the print within 3 or 4 inches of the eye. Spectacles are now obtainable constructed after the manner of miniature opera glasses, with two components separated by a short space. These are called telescopic spectacles, and are available for distance and for near vision. In cases of cataract in which the opacity largely obstructs the central part of the pupil, trial should be made of weak drops of atropine sulphate ( $\frac{1}{8}$  per cent. used daily). This may, by slight dilatation of the pupil, bring into action a clearer peripheral part of the lens and improve the vision temporarily. The patient should be kept under observation in case glaucoma should develop from the dilatation of the pupil.

When a cataract arrives at the stage of maturity, it is removed by the operation of extraction (see p. 262). An immature cataract is sometimes removed if both eyes are equally affected and the patient is thereby incapacitated. The risks of the operation are, however, somewhat increased.

*PROGNOSIS OF CATARACT EXTRACTION.*—The extraction of simple senile cataracts, in skilled hands, restores, in the large



majority of cases, good or fair vision. In a considerable proportion the vision is perfectly normal. In cases of complicated cataract, however, the conditions are entirely different. The operation is then often undertaken as a forlorn hope. If there is a possibility of restoring some degree of vision to a blind person, it is worth the attempt. What appear to be cases of almost hopeless prognosis occasionally recover very useful vision, and some cases of complicated cataract regain perfectly normal sight.

There is probably no operation on the human body in which it is more essential that the surgeon should have the confidence of his patient. The reason for this is that the operation is carried out under local anæsthesia in order to avoid the serious danger to the eye entailed by vomiting or restlessness.

**AFTER-TREATMENT of cataract cases.**—After the removal of the lens from an eye which was previously emmetropic, a high degree of hypermetropia remains. The correction of this error is accomplished by the use of a highly convex spherical lens in a spectacle frame. The correction required is usually about + 10 dioptries. In addition there is a considerable amount of hypermetropic astigmatism. This is due to flattening of the vertical curvature of the cornea, which is the result of the operation wound. The axis of the plus cylinder is required, therefore, to be approximately horizontal. For reading or other near work an addition of + 3 or + 4 dioptries to the distance correction is necessary. A weak tint of Crookes glass is of advantage for outdoor use in bright weather.

**Cataract Resulting from Intraocular Neoplasm.**—In order to complete the list of causes of cataracts, the rare occurrence of cataract following sarcoma of the choroid should be mentioned. It is probably due to damage of the capsule of the lens by direct pressure of the growth.



## CHAPTER IX

### THE VITREOUS

THE vitreous is an inert gelatinous substance, whose function is to act as one of the refractive media of the eye. It has no vessels and depends for its nutrition on fluid coming mainly from the ciliary body. It is probably epiblastic in origin, and derived from cells in the region of the pars ciliaris retinae. It is not mesoblastic, as was formerly held. The fine, transparent trabeculae, which form the meshes of the "gel," become condensed near the surface into what is known as the hyaloid membrane. The presence of this membrane has been disputed from time to time, but recent work goes to establish its existence. The hyaloid is attached anteriorly to the pars ciliaris retinae and posteriorly to the optic disc. Elsewhere, it merely lies in contact with the inner surface of the retina.

### CONGENITAL ANOMALIES

(1) **Muscae Volitantes.**—These comprise the transparent filaments, flocculi and black specks, which are best seen subjectively when looking at a bright, evenly illuminated surface. They are due to the incomplete disappearance of the vast number of cells present in the embryonic vitreous, the cells remaining, casting shadows on the retina and so becoming visible. They are of no pathological importance, and the only treatment for them is to tell the patient not to look at them. Such opacities are not seen with the ophthalmoscope even with the patient's pupil dilated. This distinction is important, since the presence of pathological vitreous opacities may indicate grave intraocular disease. If, therefore, a patient complains of floating opacities in front of the eyes, a complete examination of the fundus and refracting media must be made before assuming that they are only muscae. Entoptic opacities are sometimes noticed by patients with early cataract. In such cases, however, the opacities are fixed, and do not float about.

(2) **Remnants of the Central Hyaloid Artery.**—The only trace of this artery normally present in a new-born child is a short,



slender cord attached to the disc, which cord disappears during the first year of life. In some cases, however, the artery may persist in one of the following ways :—

(a) As a complete vessel, containing blood, and associated with the presence of fibrous tissue in the vitreous.

(b) As a vascular or avascular filament of variable length, attached at one end to the disc, the other end lying free in the vitreous. There may be a posterior lens opacity as well.

(d) As an opaque patch, a little to the nasal side of the posterior pole of the lens, with or without a tag of fibrous tissue passing back into the vitreous. Traces of some such remnant are found in most normal eyes if they are carefully examined with the slit lamp and corneal microscope.

(e) As a grey membrane filling the physiological cup in the optic disc. This membrane represents the cellular sheath which surrounded the posterior part of the artery, the artery itself having disappeared.

(3) **Coloboma of the vitreous** is rare. It is due to imperfect closure of the primitive ocular cleft and ingrowth of fibrous tissue.

### TRAUMATIC AFFECTIONS

(1) **Foreign bodies**, escape of vitreous and dislocation of the lens are dealt with in the section on injuries.

(2) **Hæmorrhages** are a frequent result of severe blows on the eye, especially if myopia is present. They are due to rupture of intraocular blood vessels, and vary in amount according to the condition of the vessels and the degree of injury.

With the ophthalmoscope they may appear as black masses floating about and obscuring the fundus reflex. If the hæmorrhage is a large one, no fundus reflex can be seen. If the blood extends to the anterior part of the vitreous, it may be visible on oblique illumination as a pinkish red mass lying behind the lens. For treatment see p. 98.

The hæmorrhage may absorb in the course of a month, if not too large. Siderosis bulbi (p. 104) may occur, and sometimes the clot is organised into fibrous tissue. The prognosis in these cases is doubtful until the hæmorrhage has cleared up sufficiently to allow of fundus examination, since there may be a lesion, such as a tear in the choroid, a detachment of the retina, etc.

### INFLAMMATORY AFFECTIONS

Since the vitreous is an avascular epiblastic structure, the phenomena of inflammation—in the pathological sense—do not



occur, *i.e.*, there is no such thing as a true hyalitis. The vitreous, however, is surrounded by vascular structures; when these become inflamed changes occur in it. Ophthalmoscopically these changes are shown by the presence of vitreous opacities, which are of varying size and are situated at various depths. They represent inflammatory exudate from the affected part of the eye. The finer varieties are best seen by the direct method with the small plane mirror of the ophthalmoscope (p. 29). Coarser opacities are visible with the large plane mirror held 1 metre or so away from the patient (p. 23). The principal varieties are as follows:—

(1) **A fine haze or veil**, composed of numerous dust-like opacities, usually lying well forward, but sometimes occupying the whole vitreous. This type is frequently due to syphilitic uveitis, or retinitis, but can occur in association with disease due to focal infections. It is important to recognise whether any haze is present in the vitreous, before examining the optic disc, as it makes the edges of the latter appear blurred, so as to resemble the condition seen in optic neuritis.

(2) **Definite Flakes and Threads**.—The presence of these is usually associated with synchysis, or liquefaction of the vitreous, so that they move about a good deal, and may be at any depth. They are usually due to chronic affections of the choroid or ciliary body; sometimes the posterior end of a threadlike opacity may be seen adhering to the focus of choroido-retinitis from which it originated.

(3) **Definite membranes**, occurring as an after-result of severe intraocular inflammation. They may cause shrinkage of the eye (phthisis bulbi) by their cicatricial contraction, and may also give rise to detachment of the retina. Particularly dense membranes are found in some cases of cyclitis (p. 161). The treatment of these conditions is primarily that of the causative lesion. For example, in a case of vitreous haze where there was choroido-retinitis due to septic absorption from infected tonsils, the haze disappeared within two months of removal of the tonsils. The larger opacities, however, do not clear up so quickly, as they become organised into fibrous tissue. In fact, they often remain permanently, even after removal of the cause. In the absence of a causative indication, reliance is placed on "absorptive remedies," such as mercurial inunctions, potassium iodide, syrup of hydriodic acid, saline purges and diaphoretic treatment by means of hot-air baths.



(4) The opacity may be due to **the presence of pus** as in panophthalmitis (p. 155), when enucleation is usually required.

(5) The opacity may be due to **hæmorrhage** in cases where the inflammatory process has involved some intraocular vessel. Some of these cases are of obscure ætiology. Thus Eales' disease (of recurrent vitreous hæmorrhage in young men, less often in young women) has been ascribed to tubercle, syphilis, oxaluria, gastro-intestinal infection, constipation, etc.

(6) It is possible for **cysticercus** to occur in the vitreous. Embryos, set free in the stomach, pass into the choroid *viâ* the blood stream, find their way out into the subretinal space, and then through the retina, into the vitreous. When first seen, they appear as a bluish-white bladder, which may undergo spontaneous movements. It is soon obscured, however, by the formation of veils around it. If the cysticercus is not removed the eye is eventually lost from iridocyclitis.

#### DEGENERATIVE CHANGES

may take the following forms :—

(1) **Synchisis or liquefaction** may occur as a simple senile change, or be due to inflammation of surrounding structures. It is also present in high myopia, presumably on account of the stretching, to which the vitreous is subjected.

(2) **Synchisis Scintillans**.—In this condition there are numerous crystals floating about in the liquefied vitreous. They are usually formed of cholesterin, but tyrosin and phosphates may occur. The condition may be present in an otherwise normal eye, and cause little or no impairment of vision, or it may be due to old hæmorrhages. Ophthalmoscopically, the appearance is suggestive of "golden rain," owing to the irregularity and highly refractive nature of the crystals, which have a golden lustre.

(3) **Muscæ or "Floaters."** With the occurrence of synchisis there is usually associated the formation of a variable number of floating vitreous opacities, which are visible with the ophthalmoscope. Their presence is an almost normal concomitant of senility and of high myopia. They are sometimes troublesome to patients, but are often hardly noticed.

No treatment is required unless they are inflammatory in origin. If very troublesome, the effect of absorptive medication may be tried, and if this fails a trial may be made of subconjunctival saline injections (5 to 10 per cent.).

(4) **Hæmorrhages**.—In addition to the conditions mentioned,



hæmorrhages may occur in the vitreous as a result of degenerative changes in the surrounding retinal vessels. Thus an atheromatous vessel may suddenly give way with escape of a considerable quantity of blood. Also in cases of venous thrombosis (p. 195) there is frequently an escape of blood into the vitreous, not necessarily at the time of the lesion, but often months, even years afterwards, the condition tending to recur. Other causes are blood diseases, such as the various forms of anæmia, purpura, scurvy, hæmophilia, etc.

TREATMENT must obviously be directed to the cause, and a thorough general survey of the patient is demanded. Thus a complete blood count should be done, the blood coagulation time estimated, search made for areas of focal sepsis, the heart and lungs carefully examined, and the blood pressure taken. Local measures in a recent case comprise rest in bed for several days, with hot applications to the eye, and administration of mild laxatives, to prevent constipation and straining. Later iodides and absorptive medication are indicated. In this way large and even massive hæmorrhages may eventually be absorbed.



## CHAPTER X

### RETINA

**The retina** during life is a delicate transparent membrane, of a faint purple colour, and forms the innermost coat of the eye. It is therefore invisible with the ophthalmoscope, and all that can be seen is its system of vessels and the reflex from the fovea (Fig. 123). The yellowish-red fundus reflex is due to light reflected by the layer of pigment epithelium and by the choroid. The appearances may vary, owing to predominance of pigmentation in one or other structure. Thus :—

(1) In an *albino* (Fig. 124) there is no pigment in the pigment epithelial layer, so that the choroidal network of vessels shows through. Pigment is also very sparse in the choroid, so that the vessels are seen on a yellowish-white background.

(2) In a case where there is little retinal pigment, but a considerable amount in the choroid, the vessels of the latter are seen against a dark background—*choroid tigré* or *tesselated fundus* (Fig. 125). The retinal pigment may be diminished as a result of disease—*e.g.*, pigmentary degeneration of the retina—or the diminution may be congenital. Care is needed to distinguish between the two varieties.

(3) With *normal pigmentation* of both membranes the fundus reflex is a more or less uniform yellowish-red colour (Fig. 123).

(4) With excessive pigmentation the *negroid* type is developed.

**The optic nerve** is seen as a light pink disc, and radiating from it are the arteries and veins. These are end vessels and do not anastomose. The mode of branching can be seen from Figs. 123, 124 and 125. Only the five principal branches are named, viz., superior and inferior, both nasal and temporal and the macular branches. The fovea is situated  $2\frac{1}{2}$  disc diameters to the temporal side of the optic disc, and may be seen as a small bright spot in the centre of the darkish red macular area. The visibility of the foveal reflex varies in different subjects.

After death the retina becomes opaque, and in a bisected eye is seen as a delicate white membrane, attached at the disc and



PLATE IX.



FIG. 123.—Normal European fundus with a conspicuous fovea centralis.

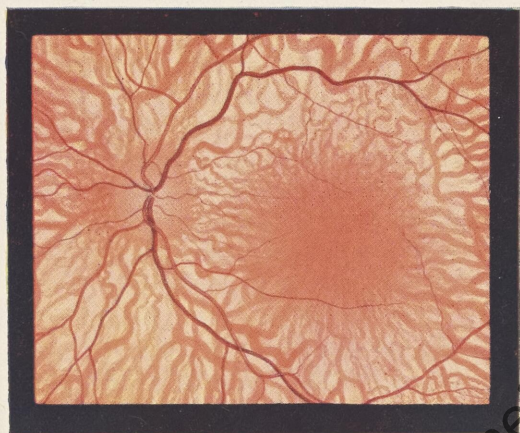


FIG. 124.—Albinotic fundus. Absence of pigment in choroid and retina allows choroidal vessels to be seen.

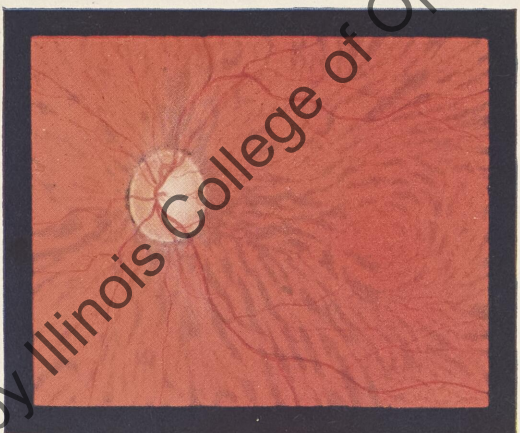


FIG. 125.—Tessellated or tigroid fundus. Deficiency in retinal pigment renders choroidal pigment visible between vessels of the latter.

*Drawings by Hamblin.*

[To face p. 188.]



ora serata, and elsewhere lying merely in contact with the pigment layer. It shows a yellowish-green area at the macula. Microscopically it can be seen to pass forwards in a modified form over the ciliary body and iris.

The retina, which is really a part of the brain, shows three layers of neurones held *in situ* by sustentacular glial fibres. The rods and cones form the outermost layer and are adjacent to the pigment epithelium. For further details see text-books on histology.

### DISEASES OF THE RETINA

may be classified under the following headings :—

(1) **Developmental.** — The most important developmental anomalies are :—

*Opaque or medullated nerve fibres.* Within the first few months after birth the optic nerve fibres become medullated as far forward as the lamina cribrosa, but remain unmedullated within the eye. Occasionally medullation of the nerve fibre layer of the retina may occur. Ophthalmoscopically the fibres form brilliant white patches with a characteristic feathered edge. They are most commonly found at the upper and lower margins of the disc (Fig. 126, p. 50), but may extend for some distance. At times isolated patches are found on the retina, unconnected with the disc. Should the retinal blood vessels pass through a patch, they are partially covered by it. There is not usually any disturbance of vision, but the blind spot is apt to be enlarged.

*Congenital pigmentation* is characterised by the presence of chocolate-brown pigment spots, angular in outline, and usually restricted to a particular quadrant of the fundus. They are of no pathological significance, and are probably due to a local failure in formation of the rods and cones, permitting the forward migration of pigment cells. Albinism has already been considered.

(2) **Traumatic Affections.**—*Anesthesia of the retina* is the mildest form of traumatic affection. The condition may follow a blow on the eye, and is characterised by amblyopia of varying duration with some loss of visual field. The eye appears normal with the ophthalmoscope, and prognosis is good.

*Comotio Retinae.*—Here there are definite ophthalmoscopic changes due to the development of retinal oedema a few hours after the blow. The part affected is diametrically opposite the site of primary injury, and is, therefore, usually in the neighbour-



hood of the disc and macula. The œdematous part appears as a whitish cloudy area, tending to increase a little in size. There may be a few small hæmorrhages. The cloudiness disappears in a few days, and vision may come back to normal.

*Hole at the Macula.*—In commotio retinæ, if the fluid is not entirely absorbed, some of it collects into a small cyst under the macular region. In course of time this cyst bursts into the vitreous with the formation of a hole. Ophthalmoscopically this is seen at the macula as a depressed area with a red floor, about half the diameter of the optic disc. The edges are usually sharply defined, but in some cases are cloudy. Central vision is consequently diminished, but is not necessarily lost in all cases.

*Eclipse Blindness.*—This is a generic term for injury to the retina sustained as a result of looking at an excessively bright light. In milder cases a temporary scotoma is developed, with metamorphopsia; in severe cases the scotoma is permanent, and slight pigment changes are found at the macula.

Treatment of these conditions is symptomatic. Thus it is advisable for the patient to wear dark glasses during the period of recovery and to restrict the use of his eyes as much as possible. Strychnine is of benefit in hastening recovery.

*Lacerations.*—The retina is a comparatively tough membrane. Thus after an injury one frequently finds a tear in the choroid with the overlying retina intact. Should a tear occur, it may have serious consequences. Thus a peripheral tear, while not affecting vision to any marked extent, renders the eye liable to develop a retinal detachment (*vide infra*), while a central tear may pass through the macular region and abolish central vision, or cause a large loss of field from interruption of the nerve fibres.

*Hæmorrhages* are considered on p. 184. It remains to add that a pre-retinal (subhyaloid) hæmorrhage may completely absorb vision without any effect on vision. An intra-retinal hæmorrhage, however, will cause some permanent damage.

**Detachment of the Retina.**—It has already been mentioned that the retina, except at the disc and ora serrata, is not attached to the pigment epithelium, but merely lies in contact with it. The retina, therefore, can readily come forward under the following conditions

(1) *Propulsion from Behind.*—This occurs in acute choroiditis, where there is a considerable amount of exudate, in retro-retinal hæmorrhage, in cases of new growth of the choroid, and in glioma



exophytum (*vide p. 197*). When the retina comes forward in this way, a corresponding amount of fluid is, of course, squeezed out of the meshes of the vitreous.

(2) *Traction from Within*.—If sufficient traction be exerted on the retina, a partial vacuum will result in the sub-retinal space and fluid will be exuded from the choroidal capillaries, thus allowing the retina to come forward. Such cases occur when the vitreous shrinks as a result of cicatricial contraction of fibrous tissue bands formed in irido-cyclitis. By far the greater number of retinal detachments occur in myopes, and various theories have been advanced to account for this. According to one of these, it is due to the degeneration of the vitreous which takes place in myopia, leading later to actual shrinkage.

(3) *The Presence of Holes or Tears in the Retina*.—If a gap be present in the retina the vitreous may at any time herniate through into the sub-retinal space and so cause a detachment. This is especially likely to occur if the intraocular tension be suddenly raised, *e.g.*, by a blow on the eye, the strain of lifting a heavy weight, etc. The occurrence of retinal detachment in myopes is frequently preceded by trauma, and holes can be seen in the retina in about 30 per cent. of cases, so that there is considerable evidence in support of this theory. Another way in which holes may form is the following: A frequent result of choroido-retinitis is adhesion between the affected parts of the two membranes. If the vitreous should now shrink, it will drag the unaffected retina inwards, causing the formation of a tear between the attached and unattached portions.

**SYMPTOMS**.—These depend on the extent of the detachment, vision being lost over the area affected. It is important, therefore, to take the patient's field of vision. The onset may be preceded by metamorphopsia and photopsia, owing to traction on the retina; in other cases it is quite sudden, and the first thing noticed is a "cloud" or "curtain" obscuring vision in the part affected.

**SIGNS**.—With the plane mirror at a distance, the character of the fundus reflex may alter, becoming greyish-white over the detached area. With the direct method (i.) the retina, being forward, can be seen with a  $+4$  lens; it is frequently visible with a  $+12$ . (ii.) It may appear greyish, though in early cases it retains its transparency. (iii.) The vessels appear almost black and are unduly tortuous, owing to folds in the retina. (iv.) There are usually abundant vitreous opacities. (v.) The retina appears to float about as the eye is moved.



**COURSE.**—The initial detachment may develop anywhere—most commonly above. Later, in serous detachments, the fluid gravitates down and the detachment is present only below. It tends eventually to become total, the retina remaining attached only at the disc and ora serrata.

**DIAGNOSIS** of the retinal detachment can usually be made from the foregoing signs and symptoms. It is of vital importance, however, to be able to say whether the condition is due to a sarcoma of the choroid or not. The points are summarised in the following table :—

	Simple Serous Detachment.	"Malignant."	Due to Hæmorrhage or its Products.
HISTORY . . . .	Usually some trauma.	Not necessarily trauma.	Possibly preceding trauma.
INTRAOCULAR TENSION	Diminished or normal.	Often raised.	Variable.
REFRACTION OF THE EYE.	Usually myopic.	Of no significance.	Of no significance.
APPEARANCE . . .	Retina floats about. Vitreous opacities.	Retina firm and solid looking unless a serous detachment is also present.	Retina firm and solid looking. There may be vascular anomalies in fundus.
TRANSILLUMINATION .	Negative.	Positive if growth far enough forward to be reached.	Often positive.
EFFECT OF TREATMENT	Retina may go back or detachment shift its position.	No effect on progress.	Little or no effect.
FIELD . . . . .	Demarcation line between blind and seeing portions not quite definite.	Demarcation line more definite.	Demarcation line more definite.

**TREATMENT** of serous detachment. Complete rest in bed in the dorsal position, with a pressure bandage over the eye, inunction with ung. hyd. oleate, 10 per cent., and the use of a hot-air bath to promote sweating may bring about reposition in four to six weeks. If this fails the operation of cautery puncture (p. 277) may be tried.

**PROGNOSIS** is bad, and treatment fails in a large proportion of cases, especially if a hole is present in the retina.

(3) **Inflammatory.**—Inflammation, in the strict pathological sense of the word, does not occur in the retina, but deposits of inflammatory cells may occur on the surface of the retina and





FIG. 127.—Renal or albuminuric retinitis. Note blurring of edge of disc, striate hæmorrhages, macular star figure, soft-edged “cotton-wool patches” and hard, white dots.

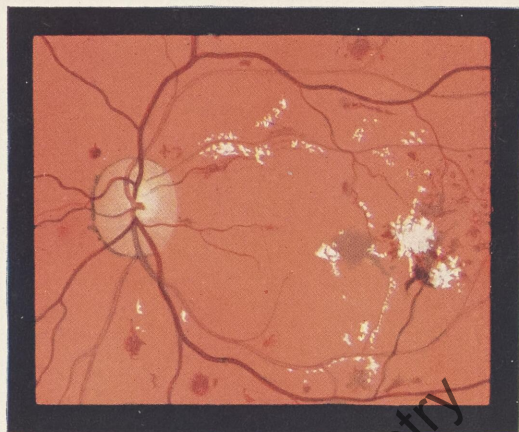


FIG. 128.—Diabetic retinitis. Note blot hæmorrhages, hard white dots, absence of star figure.

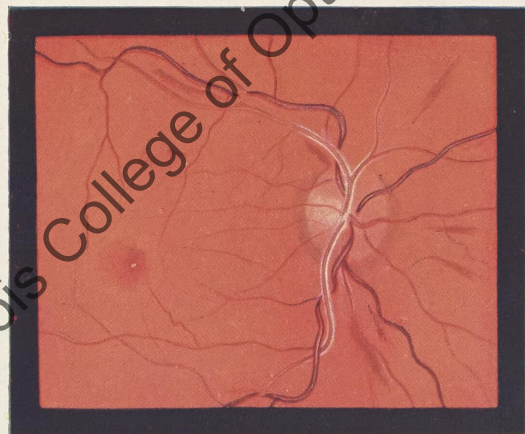


FIG. 129.—Retinal arterio-sclerosis. Note striate hæmorrhages, irregular calibre and white sheathing of arteries, indentation of veins at arterial crossings.

*Drawings by Hamblin.*

[To face p. 193.]



infiltration take place around the vessels; otherwise retinitis occurs only by extension from the choroid, *e.g.*, in tubercle and syphilis. Various changes, however, occur as a result of disease, and these are grouped clinically under the heading "retinitis." The principal varieties are:—

*Renal Retinitis.*—This may be seen in all forms of chronic nephritis, but is most commonly associated with contracted granular kidney. It also occurs in pregnancy nephritis. It is usually bilateral and central vision may be markedly diminished, though not always. The cause is in all probability a toxic substance formed by decomposition of the kidney. The commonest age is from thirty to forty.

A typical case (Fig. 127) shows the following ophthalmoscopic features: Swelling of the disc and haziness of its edges, venous engorgement, hæmorrhages on the disc and in the nerve fibre layer, and development of white spots. These are of three kinds: (i.) Soft "cotton-wool" patches generally near the disc but also in other parts of the fundus; (ii.) fine white patches of degenerate varicose nerve fibres and cytoid bodies; (iii.) fine white dots arranged in lines which converge on the macula. In some cases a complete star figure is formed; in others there may be only a "fan" passing towards the disc. None of these changes is necessarily pathognomonic of renal retinitis, but the grouping of the whole is suggestive, though very similar appearances may be seen in diabetes and cerebral tumour. Occasionally a retinal detachment may occur, especially in pregnancy cases. In these latter the prognosis is quite good, both with regard to the eye and to life. In the other cases the prognosis is bad, the majority dying in eighteen months to two years.

TREATMENT is necessarily that of the renal condition.

*Diabetic retinitis* may bear a close resemblance to the renal variety, but distinguishing characteristics are often present (Fig. 128). They are as follows: The hæmorrhages tend to occur in the deeper layers of the retina and are therefore punctate or blot-like rather than striate. Cotton-wool patches are not common, and white masses when present are more waxy in colour and have more definite outline. Glistening dots occur in the macular region, but are seldom arranged in a star figure. All sorts of fundus changes may occur in diabetes; thus embolism of the central artery, thrombosis of the vein, retinitis circinata, or even optic atrophy may be the sole manifestation. The importance of urine analysis in such cases is therefore obvious.



*Leucæmic retinitis* is present in about 30 per cent. of cases of leucocythæmia. The appearances vary, but characteristic features are an orange reflex, pallor of the blood vessels, enlargement of the veins, small hæmorrhages, and the formation of round, white spots up to 2 mm. diameter. These spots are fringed with blood and develop in the periphery of the fundus or at the macula.

(4) **Vascular Conditions.** — *Arterio-sclerosis.* — The principal changes are : (i.) Irregularity in the lumen of the arteries with tortuosity and the presence of a bright linear reflex from their surface, the line being sometimes broken up into dots ; (ii.) considerable nipping or indentation of the veins where they are crossed by the arteries, the latter tending to pass over them at right angles instead of following the more usual oblique course ; (iii.) the presence of small flame-shaped hæmorrhages in posterior parts of the fundus (Fig. 129). Later, a form of retinitis may develop characterised by the formation of small white patches with sharp edges in the region of the macula.

Prognosis in these cases is dependent on the associated cardiac and renal changes and is not nearly so bad as in renal retinitis.

*Retinitis proliferans* is a name given to the formation of bands of vascularised fibrous tissue which may ensue as the result of organisation of hæmorrhage into the vitreous. They usually pass forwards from the disc to the anterior portion of the retina, and by their contraction may cause detachment of that membrane.

*Retinitis circinata* is another result of retinal hæmorrhages. It consists in the formation of bright white patches arranged in a more or less circular manner around the macula. The radius of the circle may be a disc diameter or more. The macular area is greyish in colour from pigmentary disturbances, and may show some hæmorrhages.

*Embolism of the Central Artery of the Retina* (Fig. 130).—This causes sudden and complete blindness except in those cases where the macular region is supplied by a cilio-retinal artery, when central vision may be preserved. The ophthalmoscope shows a typical picture. The retina is cedematous and soon undergoes coagulation necrosis. It therefore appears greyish white and hazy, except at the macula, where it is thinner and allows the choroid to shine through, forming a "cherry" red spot. The arteries are at first reduced in calibre, but later fill up from anastomotic channels round the nerve head. The column of blood is frequently broken up, giving it a "railway truck" appearance.

Prognosis is bad unless only a branch of the artery is involved,



as the retina dies before re-establishment of the circulation can be effected. Vision may improve for a time but eventually even perception of light is lost.

The commonest causes are endocarditis and valvular disease (an embolus being detached from one of the valves), or arterio-sclerosis, when the lesion is probably thrombotic in origin.

**TREATMENT.**—If seen within an hour of onset energetic attempts should be made to move the embolus. Thus the eye should be thoroughly massaged, and if this is unsuccessful parencentesis of the anterior chamber should be performed. Dilatation of the retinal arteries by inhalation of amyl nitrite may also be of service.

**DIAGNOSIS.**—Quinine and *Filix mas* poisoning may produce similar appearances from spasm of the artery. A somewhat similar picture is also seen in amaurotic family idiocy.

*Thrombosis of the Central Vein.*—This lesion is usually seen in old people with sclerotic arteries. In cases where only a branch is involved, the clot is formed at a point where the vein is crossed by a sclerosed artery. When the main trunk is blocked, thrombosis usually starts just behind the lamina cribosa. Ophthalmoscopically (Fig. 131) the veins are turgid and the arteries small. The disc margins are blurred and there are numerous hæmorrhages scattered over the fundus. In course of time these hæmorrhages absorb, leaving whitish areas rather resembling the cotton-wool patches of renal retinitis. It is characteristic of the condition that the hæmorrhages tend to recur, sometimes bursting into the vitreous. Prognosis is not so bad as when the artery is affected, some cases retaining fairly useful vision, though there is often a central scotoma.

**TREATMENT.**—Search should be made for focal sepsis (infected teeth, tonsils, etc.). In the early stages citric acid is indicated to aid in canalisation of the clot. It is best given in the form of lemons, six a day over a period of a month or so. After this mercury and potassium iodide are of use in aiding absorption. The patient should wear dark glasses and do no close work.

(5) **Degenerations.**—*Pigmentary degeneration of the retina* (formerly known as retinitis pigmentosa) (Fig. 132) is a hereditary form of abiotrophy in which the rods and cones lose their vitality apart from any interference with the nutrition. Following on this there is migration of pigment forward into the retina and the excessive formation of neuroglia. The part of the retina first affected is that which lies from 10 to 15 degrees from the fovea,



*i.e.*, the portion which is most sensitive in the dark adapted eye. Hence the first symptom is night blindness. Later this area becomes affected in day vision too, and a ring-shaped scotoma develops, which gradually spreads towards the periphery and more slowly towards the fixation point. There is thus a gradual decrease in size of the visual field though central vision remains fairly good, but this may eventually be lost. Posterior polar cataract is a common complication. The disease is more common in the offspring of consanguineous parents, and other congenital defects may be present, especially deafness.

**COURSE.**—The disease is, with a very few exceptions, bilateral. Night blindness may be noticed during childhood. The condition steadily progresses with age, until at sixty, even central vision may be abolished, though in some cases the process comes to a standstill, leaving some useful vision.

**OPHTHALMOSCOPIC APPEARANCES.**—The first change is the appearance of pigmentation in the mid-peripheral zone of the fundus. The pigment is aggregated into masses resembling the shape of bone corpuscles. It is also found in the perivascular lymphatics of the veins, so that they appear to be sheathed with it. Other changes are : (i.) The appearance of a yellowish reflex with unduly prominent choroidal vessels, owing to disappearance of the retinal pigment layer, and atrophy of the chorio capillaris ; (ii.) diminution in calibre of the retinal vessels ; (iii.) development of a waxy colour in the disc, owing to glial proliferation ; (iv.) sclerosis of the choroidal vessels.

**DIAGNOSIS.**—Some cases of hereditary syphilitic choroido-retinitis are very similar. They are diagnosed by the presence of other stigmata and a positive Wassermann, also by the much younger age at which the changes appear and by the degree of change being frequently more marked in one eye than in the other.

**TREATMENT.**—The administration of thyroid extract has been advocated and in some cases seems to have arrested the process. In cases where a cataract forms a remarkable improvement sometimes follows its extraction.

**Senile Macular Atrophy.**—This condition usually occurs in connection with central choroidal changes (p. 167). It may also be purely retinal, when the macular area is occupied by yellowish, red, whitish, or darkly pigmented spots. These are often difficult to see with the ophthalmoscope, but their presence explains reduction of central visual acuity in an old person with an otherwise



normal eye. Here again thyroid extract carefully administered may be of service, parathyroid being sometimes given with it.

For the rarer forms of retinal atrophy, amaurotic family idiocy, cerebro-macular disease, etc., the larger books should be consulted.

(6) **New Growths.**—Neuroepithelioma is a highly malignant tumour, due to overgrowth of the neuroepithelium of the retina. When first described it was thought to be glial in origin and was called “glioma”; by which name it is still known.

**ÆTIOLOGY.**—The tumour is most commonly seen at the age of two years and has not been met with after the age of eleven. In a few cases it has been present at birth. It is bilateral in 25 per cent. of cases, and in these the tumour arises separately in each eye, there being no continuity *viâ* the chiasma. The interval between affection of the two eyes is usually a few months, but may be as much as three years.

**HISTOLOGY.**—The growth is composed of masses of small round cells, with large nuclei and little cytoplasm, arranged in a tubular manner round central vessels. The cells bear a close resemblance to those of the foetal retina at the third month. In a few cases they develop into rudimentary rods and cones which are grouped into a “rosette” formation. Growth is so rapid round the vessels that the cells furthest away from them undergo necrosis. One therefore sees—in sections—the condition known as “mantling,” cells near the vessels taking the stain quite well, while those further away show no detail. Another characteristic is the presence of satellite growths within the eye. These are due to portions broken off from the original tumour which take root in other parts of the retina and grow there. If the growth protrudes from the outer surface of the retina it pushes the latter into the vitreous and is known as “glioma exophyllum.” If it grows into the vitreous from the inner surface of the retina, without displacing the latter, it is called “glioma endophyllum.”

**CLINICAL COURSE.**—There are four stages:—

(1) The eye is blind and there is a white or yellowish-white reflex in the pupil, due to the growth or detached retina showing through the lens.

(2) Increase of intraocular tension, with redness of the eye and pain. The eye may subsequently shrink.

(3) Extension through the optic nerve and later through the cornea and sclera, the eye becoming a large fungating mass.



(4) Metastases in the base of the skull or face. Death is usually due to cerebral involvement or sepsis and exhaustion.

The course usually extends over several years.

DIAGNOSIS is made by the presence of the white pupillary reflex occurring in a child. Inflammatory conditions of the retina, exudates behind the lens from cyclitis, and pus in the vitreous may give rise to similar appearances, and the diagnosis may at times be very difficult. In some cases the depth of the anterior chamber may afford a clue, being greater in the inflammatory conditions, and the ophthalmoscopic appearances may help. In glioma one sees either the detached retina or a light-coloured nodular mass covered with small vessels.

TREATMENT comprises prompt enucleation with removal of as much optic nerve as possible. Transverse sections should be made of the cut end of the nerve, and if any growth be present the orbit should be exenterated and radium applied. Fifty per cent. of cases are saved if operation is performed before extraocular extension has occurred. Even if the orbit is already involved exenteration affords some relief to the child, though recurrences soon develop. It is important to watch the other eye during the ensuing years in case a growth develops in it.



## CHAPTER XI

### OPTIC NERVE

#### ANATOMY

THE optic nerve may be considered in three divisions :—

(i.) **The Intraocular Portion.**—This comprises the optic disc and the intrascleral part of the nerve. The disc itself is of a light pink colour and has the vessels radiating from it. There is usually a depression in the centre, the physiological optic cup, the size of which is variable. In some cases it is scarcely present at all, while in others it is so large as to resemble the cup found in glaucoma. Its presence is due to the fact that

the optic nerve fibres are spread out within the eye, but are closely gathered together within the foramen scleræ, thus acquiring a funnel-like arrangement. The larger the foramen, the deeper will be the funnel. This foramen is more apparent than real. The lamellæ of the inner third of the sclera stretch

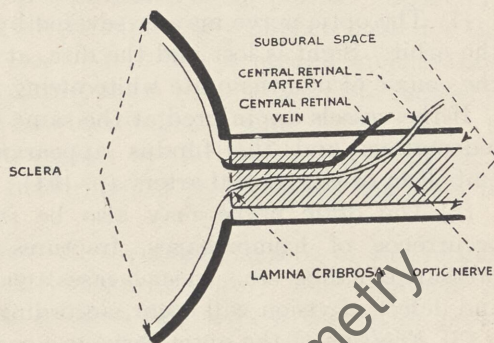


FIG. 133.—Diagrammatic section to show central retinal vessels in optic nerve.

across it in the form of a fenestrated membrane—the lamina cribrosa—through which pass the nerve fibres and vessels, while the outer two-thirds are reflected back on the nerve to join with its dural, arachnoid and pial sheaths. The subdural and subarachnoid spaces of the nerve thus end in a cul-de-sac in the sclera (Fig. 133). The fibres of the optic nerve acquire their medullary sheaths after they have passed from the retina through the lamina cribrosa, so that the nerve as a whole becomes thicker.

(ii.) **The Orbital Portion.**—This takes a somewhat S-shaped course, so as to allow of movements of the eye. The fibres vary in calibre. They are collected into bundles, supported by a connective tissue framework derived from septa which pass into



the nerve from its sheath of pia mater. The vessels in the anterior portion are placed centrally, but further back they leave the nerve on its lower and inner side, some 12 mm. behind the sclera, and pass through the subarachnoid and subdural spaces. The central vein of the retina joins the superior ophthalmic vein or goes directly to the cavernous sinus, while the artery arises as one of the branches of the ophthalmic. The membranes covering the nerve are pia, arachnoid and dura, from within outwards. The surfaces of these membranes limiting the subarachnoid and subdural spaces are lined with endothelium.

(iii.) **The Intracranial Portion.**—This passes through the bony optic foramen, which contains also the ophthalmic artery, lying on the inner side of the nerve. The dural and arachnoid sheaths unite with the corresponding membranes of the brain, and the nerve passes on to the chiasma.

### TRAUMATIC AFFECTIONS

(1) The optic nerve may be severed by *direct injuries* involving the orbit. Sight is lost and the disc, at first normal, becomes in the course of months quite white owing to a descending atrophy.

If the vessels are injured at the same time, the retina becomes œdematous and the fundus appearances resemble those in embolism of the central artery (p. 194).

(2) The optic nerve may also be *injured indirectly* by the occurrence of hæmorrhages, fractures of the optic foramen, pressure of callus, etc. In such cases a varying amount of atrophy and defect of vision will occur, according to the degree of injury.

(3) *Evlulsion* of the optic nerve is a rare condition following an injury which has been severe enough to tear the optic nerve away from the eye. The result is, of course, blindness and the formation of a deep crater-like hole at the disc.

(4) The optic nerve may be injured by *chemical substances*. Under this heading may be grouped those cases known as **Toxic Amblyopia**, though they are not all strictly traumatic in origin.

A. The toxin may be *endogenous* in origin, as in—

- (i.) Diabetes, where there may be failure in vision with development of a central scotoma for colours.
- (ii.) Uræmia, where there are transient attacks of blindness, probably due to some temporary interference with the higher visual centres.
- (iii.) Pregnancy and the puerperium, where temporary amblyopia may occur apart from uræmia or nephritis.



B. The toxin may be *exogenous*, e.g. :—

- (i.) Tobacco, usually of the shag variety, or in the form of strong cigars. The ganglion cells in the macular region of the retina are probably attacked primarily. In consequence of this the patient develops in both eyes a central scotoma, first for colours and later for white objects, with considerable diminution of visual acuity. The patients see better in subdued lights, because the peripheral portion of the retina is not affected. The condition seldom occurs before the age of thirty-five, since vascular sclerosis is probably a contributory factor. If the patient be already diabetic, he becomes more sensitive to nicotine. Treatment consists in complete abstention from tobacco in any form, restriction of alcohol, and administration of a strychnine mixture. The patient should be advised to drink large quantities of water to aid in elimination of the poison. He should also be warned not to expect any improvement for the first month or so. After this a steady amelioration occurs, and eventually there may be complete recovery, if the condition has been taken in time.
- (ii.) Ethyl alcohol acts mainly by the production of vascular sclerosis, thus rendering the eyes more vulnerable to tobacco, etc.
- (iii.) Methyl alcohol acts on the ganglion cells of the retina, but more violently than tobacco. The blindness is usually complete at first, and later a central or para-central scotoma may be left.
- (iv.) Carbon disulphide and iodoform act in the same way.
- (v.) Quinine, *Filix mas*, aniline and arylarsonates (e.g., atoxyl) cause defective vision by bringing about constriction of the arteries. The condition cannot be called amblyopia, since fundus changes occur which bear a strong resemblance to those seen in embolism of the central artery (p. 194). Prognosis is variable. Some of the quinine cases recover quite well; in others there is a permanent contraction of field. With nitrobenzol complete recovery is more likely. Optic atrophy has frequently followed poisoning with atoxyl, but has never been known to follow administration of salvarsan or its derivatives. With *Filix mas* one eye may remain blind, and the other recover nearly normal vision. Ergot



may cause some transient blindness from vascular spasm, but the effect is never permanent.

(vi.) Lead and silver nitrate may cause blindness by inducing an acute encephalitis, or the defect in vision may be secondary to the renal changes they produce.

(vii.) The temporary blindness produced by large doses of salicylic acid is probably cortical in origin.

(5) *Visual disturbances following distant hæmorrhage*, the site of which is most commonly the intestine or uterus. The disturbance is usually bilateral, varies from serious embarrassment to complete blindness, and does not occur until three to four days after the hæmorrhage. Most cases improve, but only 10 per cent. recover good visual acuity. The fundus appearances are usually those of retinal œdema, going on to optic atrophy.

### INFLAMMATORY AFFECTIONS

It is necessary to draw a distinction between cases where the disc changes are due merely to passive œdema and cases where they are caused by actual inflammation. The former condition is known as *papillœdema*, the latter as *optic neuritis*. Ophthalmoscopically they may be very similar, but clinically there is often a great difference, in that vision may be scarcely affected at all in early papillœdema, whereas in optic neuritis it may be seriously impaired. **Papillœdema** occurs most commonly in connection with raised intracranial pressure. The subdural space of the optic nerve is normally continuous with the general subdural space. Any increase in pressure of the cerebrospinal fluid will, therefore, be transmitted to the fluid occupying this space, and will tend to compress the central retinal vessels as they traverse it (*vide* Fig. 133). The artery is relatively unaffected, on account of the high pressure of the blood it contains. The blood in the vein, however, is at a low pressure, so that stasis is easily brought about. This stasis is not only venous, but it is also lymphatic, as the lymphatics of the optic disc pass out in the walls of the vein. Since the intraocular pressure remains normal, it follows that the disc will become œdematous and will swell, owing to the stasis of blood and lymph. Another consequence is that hæmorrhages will occur.

Clinically, papillœdema has been found in 80 per cent. of cases of cerebral tumour which have been under observation until the time of death or operative cure. It was present in all cases of cerebellar, temporo-sphenoidal or fourth ventricle tumours,





FIG. 134.—Papilloedema, first stage. Note blurring of upper and lower margins of disc.

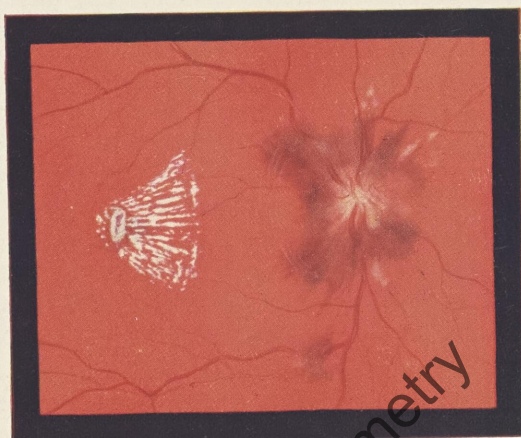


FIG. 135.—Papilloedema fully developed. Note hæmorrhages, concentric striation, round disc, soft whitish patches and macular fan.

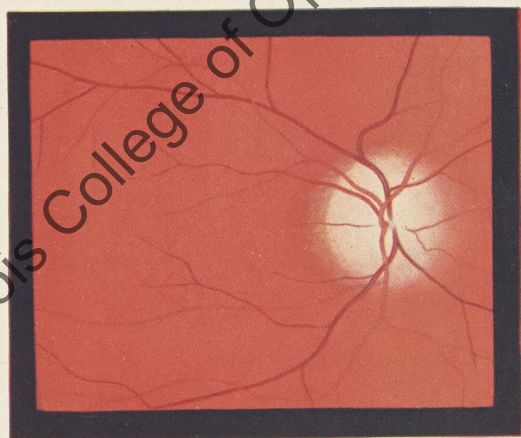


FIG. 136.—Consecutive optic atrophy. Note blurred edge and pallor of disc, and smallish vessels.

*Drawings by Hamblin.*

[To face p. 203.]



and absent in purely pontine growths, though it developed if the growth extended from the pons, say, to the cerebellum. It was present in roughly 50 per cent. of subcortical cases, and 75 per cent. of extracerebellar, thalamic and mid-brain tumours. The presence of papillœdema on one side and not the other has no localising value. In some pituitary and frontal cases there may be papillœdema in one eye and a simple pressure atrophy of the nerve in the other. This is because direct pressure on the chiasma or nerve blocks the subdural space on one side so that the increase in pressure cannot be transmitted along it.

OPHTHALMOSCOPIC APPEARANCES.—The following stages are recognised in the development of papillœdema :—

- (1) Blurring of upper and lower margins of disc (Fig. 134).
- (2) The disc becomes more red, the œdema spreads down its nasal side and the veins become more tortuous and engorged.
- (3) Blurring spreads round the disc, the arteries become buried in the swollen tissue and the veins very conspicuous (Fig. 135). The physiological cup may or may not fill in, and hæmorrhages appear in 50 per cent. of cases. Owing to lateral bulging of the nerve head, the retina may become rucked up into concentric folds. The nerve fibres swell up and become varicose, giving a stippled appearance to the swelling and bringing about the formation of softish white areas. Capillaries also develop on the disc.
- (4) In cases where the œdema has developed very rapidly, it may overrun the temporal margin of the disc to form a grey wedge with its apex at the macula. The fluid in this wedge settles down along the lines of the nerve fibres, and, later, forms a " macular fan " (*vide* Fig. 135).
- (5) After the œdema has existed for some time, neuroglial overgrowth appears. This gives the disc an opaque white appearance, and by its contraction causes diminution in the swelling. The vessels are also compressed and the eye eventually becomes blind from consecutive atrophy of the optic nerve (Fig. 136).

DIAGNOSIS.—(1) In stages 1 and 2 this may be very difficult and depends principally on the amount of swelling of the disc. This is measured as described on p. 32. In many cases of hypermetropia the edge of the disc may be blurred and there may even be a little swelling, which, however, remains stationary. This condition is known as "pseudo-papillœdema." Cases may thus have to be watched for some months before a definite diagnosis can be made.

- (2) In the later stages, the fundus changes may resemble those



seen in thrombosis of the central vein and in renal retinitis. Here again the amount of swelling is of use, being higher in papilloedema; also the vision is likely to be much better.

Fields should always be taken, and there may be other localising signs. Temporary blindness, from intermittent pressure of a distended third ventricle on the chiasma, is at times a valuable symptom.

TREATMENT is that of the causative condition, *e.g.*, intracranial neoplasm, gumma, tuberculoma. In the absence of localising signs, a palliative decompression to save vision is indicated if neuroglial overgrowth has not already begun, *i.e.*, if the disc is still of a good colour and the vessels are not reduced in calibre.

**Optic Neuritis.**—This may affect various parts of the nerve :—

(1) *Intraocular, i.e.*, papillitis when the edges of the disc are blurred, the vessels being engorged and the disc itself somewhat swollen. The lesion is commonly associated with retinitis, as in the renal and diabetic forms. In syphilis, tubercle and disseminated sclerosis, however, if the focus of infection happens to be in the nerve head, intraocular neuritis will occur without retinitis. Occasionally a descending infection, as in cerebro-spinal meningitis and orbital infections, may give rise to the condition, and it has been seen in chlorosis, suppression of menstruation, peripheral neuritis, etc.

(2) *Retro-ocular or Retrobulbar.*—In these cases there is rapid loss of vision in one or both eyes, without ophthalmoscopic changes in the early stages, though these may occur later. The condition is often preceded by supra-orbital neuralgia and is accompanied by pain on movement and palpation of the eye. A characteristic pupil reaction may be present; if so the pupil on the affected side is a little dilated and reacts to light, but the contraction is not well maintained and it soon dilates again.

The field changes are also characteristic and comprise the development of a "cæocentral" scotoma, *i.e.*, one involving the fixation point and the blind spot. In a mild case the scotoma may be only for colours (especially red and green); in a more severe one, perception of white is also lost in the affected area. Some cases develop photophobia.

*Causes* may be local or general. The local comprise : (1) Orbital inflammation, generally due to extension from infected sphenoidal or ethmoidal sinuses; and (2) hæmorrhage into the nerve sheath following a blow on the eye. The general causes include syphilis, septic infarcts from focal infections (teeth, tonsils, etc.), or



influenza or one of the specific fevers. In some cases no cause can be found, while others represent an early stage of disseminated sclerosis—a possibility which must always be borne in mind, especially if there be a previous history of transient diplopia. A familial form of retrobulbar neuritis is also known, under the name of “Leber’s atrophy,” which develops a few years after puberty. The disease is limited to males, but transmission occurs through the unaffected mother. Both eyes are attacked at a variable interval, and the resulting central scotoma and optic atrophy cause gross diminution of visual acuity. In some cases improvement, falling short of complete recovery, has been noted. The cause of the disease is doubtful. It has been assigned by some to pressure exerted by the pituitary body, which enlarges at the time of puberty.

*The diagnosis* rests usually between retrobulbar neuritis and toxic amblyopia. It can, in most cases, be made by the absence of pain in the latter and by the fact that retrobulbar neuritis may attack only one eye, whereas toxic amblyopia is bilateral.

*Treatment.*—The first essential is to look for one of the causes already mentioned and to treat it as thoroughly as possible, special attention being paid to the history, the condition of the teeth and sinuses. In idiopathic cases it is usual to administer mercury and iodides or salicylates. Diaphoresis is of doubtful value. During the acute stage the patient should be kept in bed in a warm room, and if there is photophobia the room should be darkened.

*Prognosis.*—The syphilitic cases do badly if treatment is delayed and the same is true of those due to sinus infection. On the whole, however, prognosis is good if the cause is dealt with early and an almost complete return of vision may be anticipated.

### DEGENERATIVE DISEASES

These comprise the large group of cases of optic atrophy. The characteristic ophthalmoscopic change in these is pallor of the disc, which is due to the following factors:—

- (i.) Diminution in blood supply.
- (ii.) Increase in connective tissue.

The proportion between these factors varies in different cases, e.g., in tabes the calibre of the vessels is practically normal.

Optic atrophy may be classified according to the site of the causative lesion, which may be:—

- (1) **Retinal**, in which the disc tends to be of a yellowish, waxy



colour and the vessels markedly contracted. Such a condition occurs as a result of (i.) pigmentary degeneration of the retina; (ii.) widespread choroido-retinitis or choroidal degeneration; (iii.) retinal vascular conditions (arterio-sclerosis, embolism, thrombosis, and spasm as in quinine amblyopia); and (iv.) untreated toxic amblyopia when the primary lesion is in the retina, *e.g.*, tobacco, or where the effect is to cause retinal arterio-sclerosis, *e.g.*, lead.

(2) **In the disc**, as a result of—

- (i.) Papillitis and papilloedema. This type of atrophy is sometimes termed “secondary” or “consecutive.” The usual appearances are that the disc is opaque white, the lamina cribosa being invisible, the edges uneven and blurred, while the vessels are contracted. In some cases, however, a “simple” atrophy supervenes.
- (ii.) Glaucoma in which the disc is white and deeply cupped (*vide* p. 209).
- (iii.) High myopia, in which the disc may be pale, or a lacunar type of degeneration may occur, producing an appearance like that in glaucoma (Schnäbels’ cavernous atrophy).

(3) **Behind the Globe**.—In these cases the disc tends to become bluish-white in colour, with clear edges, vessels of good calibre and a visible lamina cribosa, so-called simple or primary atrophy. Any of the factors already mentioned as bringing about retrobulbar neuritis and toxic amblyopia (excepting those substances acting directly on the retina) may cause this type of atrophy. In addition, there are trauma, pressure by tumours (*e.g.*, pituitary growths), by sclerosed arteries (*e.g.*, the ophthalmic), and spread of inflammation from the meninges, orbit, etc. The optic atrophy produced by tabes and by disseminated sclerosis must also be included in this group.

#### NEW GROWTHS OF THE OPTIC NERVE

These may be secondary to retinal or choroidal neoplasms or may be primary. The cardinal signs of the latter are:—

- (1) Proptosis, usually straight forward, the mobility of the eye remaining good for a comparatively long time (Fig. 137).
- (2) Gradual loss of vision with preceding papilloedema if the growth is far enough forward to compress the central retinal vessels.
- (3) Progressive hypermetropia owing to shortening of the eye by pressure exerted on it from behind.



*Extradural* growths are most commonly endotheliomatous—a few are sarcomatous. Vision is not affected so early as in *intra-dural* cases, and progressive hypermetropia is not so likely to occur.

*Intradural* growths are of three types :—

- (1) Gliomatosis, *i.e.*, a generalised overgrowth of neuroglial tissue of infiltrative character.
- (2) Fibromatosis of the nerve sheath.
- (3) Endothelioma, usually growing from the cells lining the

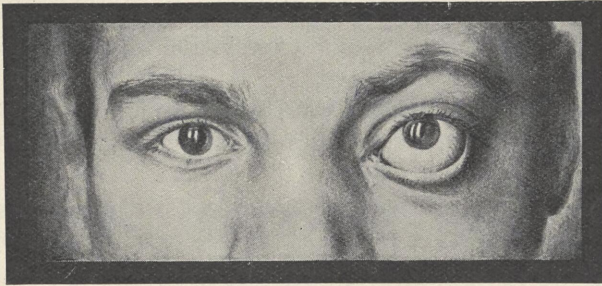


FIG. 137.—Proptosis is almost directly forwards. The upper lid is pushed forwards, the lower lid downwards and forwards. A case of tumour of the optic nerve. [Drawing by Hamblin.]

arachnoid. Some of these cases represent an extension of a similar growth from the brain, when prognosis is very bad. With this exception prognosis is good and local recurrences are rare after operation.

*Diagnosis* from an inflammatory mass, or other cause of proptosis, is at times very difficult, and demands a close investigation into the history and general condition of the patient.

*Treatment* consists in extirpation of the tumour. This may demand exenteration of the orbit, but in some cases the eye can be preserved.



## CHAPTER XII

### GLAUCOMA

GLAUCOMA is a disease of the eye characterised by the development of increased intraocular pressure. The increase may be primary, *i.e.*, unassociated with any other disease, or secondary to other disease. Glaucoma is thus divisible into the two main groups, **primary** and **secondary**.

**The signs and symptoms of glaucoma** in general are best understood by considering the effect of increased pressure in the various parts of the eye. Thus :—

(1) The *bulbar conjunctiva* ; interference with return of blood through the perforating vessels of the sclera causes congestion of the episcleral vessels.

(2) The *corneal epithelium* may become oedematous if the pressure is high enough to cause interference with the return of lymph. The cornea appears steamy when oedematous.

(3) The *substantia propria* of the cornea may become hazy from unequal traction on the interlacing lamellæ of which it is formed. This phenomenon can be shown in pigs' eyes, used for the purpose of practising operative surgery. If the stand in which the eye is held is pressed down firmly, the cornea will at once become hazy, the haze disappearing when the pressure is released.

(4) The *anterior chamber* is usually shallow on account of the advance of the lens from elevation of pressure in the vitreous.

(5) The *iris* is thus brought forwards. The root of the iris is also displaced in the same direction owing to swelling of the ciliary processes. The pattern of the iris may be clouded by oedema, and later there may be atrophy.

(6) If the pressure is high enough to cause interference with the ciliary nerves there ensues anæsthesia of the cornea and dilatation of the *pupil*, owing to paralysis of the sphincter.

(7) The *ciliary body* may become swollen from oedema, though frequently swelling of the ciliary body is the primary condition and is responsible for the onset of the disease. The ciliary muscle shows a varying degree of paresis, due probably to involvement of the ciliary nerves. This brings about premature presbyopia.



(8) The *choroid* undergoes a certain amount of pressure atrophy round the disc, causing the formation of a white circular band (Fig. 139, p. 176). This band is sometimes called the glaucomatous halo, though the term is better reserved for the halo seen round a light when the cornea is hazy.

(9) The *retina*, in an acute attack, may become almost entirely insensitive to light. In the chronic forms of the disease the optic nerve fibres are involved rather than the retina. Pulsation is seen in the retinal arteries if the intraocular pressure be higher than the diastolic arterial pressure. This condition may also occur in aortic regurgitation and exophthalmic goitre. In these cases, however, the cause is lowering of the diastolic rather than raising of the intraocular pressure.

(10) *The Optic Nerve*.—The lamina cribrosa is the weakest part of the ocular tunic and is the first to give way under increased



FIG. 138.—Thick black line indicates sclera and dura. Thin black line, retina and central vessels. Broken line, lamina cribrosa.

pressure. This, together with pressure atrophy of the overlying nerve fibres—gives rise to the formation of the glaucomatous cup. In its fully developed form, the cup is flask-shaped and has overhanging edges (*vide* Fig. 138). Ophthalmoscopically, the cup is seen as a depression whose borders reach the edge of the optic disc (Fig. 139, p. 176). The vessels are lost sight of as they pass over the edges of this depression and are visible again at the bottom of it, where they lie on the lamina cribrosa. In order to see them clearly in this position, by the direct method, it is necessary to use a lower convex or a higher concave lens than is required for the rest of the fundus. It will also be found that if the head be moved slightly from side to side, definite parallax can be obtained between the level of the lamina cribrosa and the surrounding fundus. Another characteristic feature is that the openings in the lamina are clearly visible. This is due to atrophy of the nerve fibres, which also causes pallor of the disc. The degree of cupping varies with the length of time the increased intraocular pressure has lasted and with the amount of pressure.



Another consequence of interference with the nerve fibres is the development of **field defects**. Fig. 140 is a diagram showing the course of these nerve fibres in the retina. It should be observed that on the temporal side of the retina they form a definite raphé, whereas on the nasal side they do not. Suppose now that the nerve fibres were blocked by pressure at A and B, where they curve over the sharp edge of the disc. The result would be loss of vision in the areas of retina supplied by these

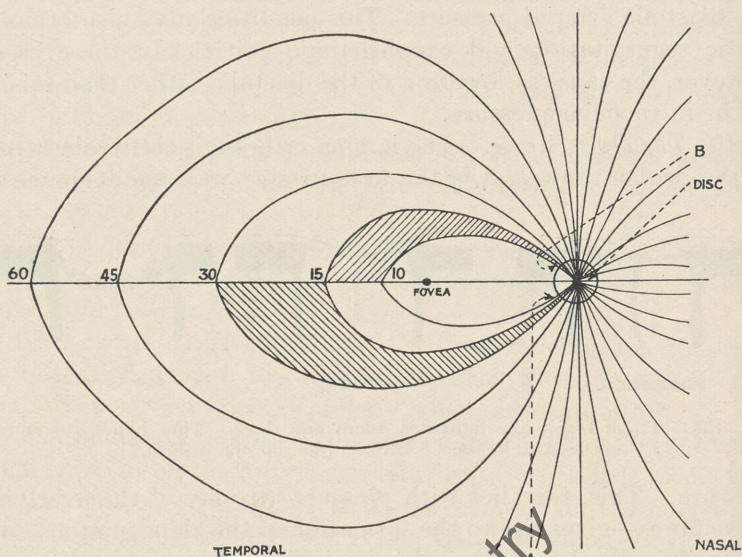


Fig. 140.—Diagram of the course of the nerve fibres in the retina. To understand the formation of the scotomata in Fig. 141, by lesions at A and B, imagine that this figure (140) represents the nerve fibres in the transparent retina of the left eye, viewed from behind. The numbers correspond with those on the horizontal meridian in Fig. 141.

fibres. These areas are shaded in the figure, and if projected on to the field of vision, would be represented by a scotoma as shown in Fig. 141, in which the lettering corresponds with that in the previous diagram. It is important to notice that, in consequence of the horizontal raphé of fibres, a definite "nasal step" may be produced in this type of scotoma. Another feature is that this scotoma is connected with the blind spot. In the early stages, it is manifest only as a wing-shaped extension (up and down) of the blind spot. This is usually one of the earliest signs of chronic glaucoma. Another common type of defect is loss of the nasal portion of the field, which usually occurs before



there is limitation on the temporal side. Increased intraocular pressure will also, of course, affect the nerve fibres coming from the macula, thus causing a progressive reduction in visual acuity.

(11) The *sclera* may stretch. This is particularly liable to occur in the young, resulting in the development of buphthalmos.

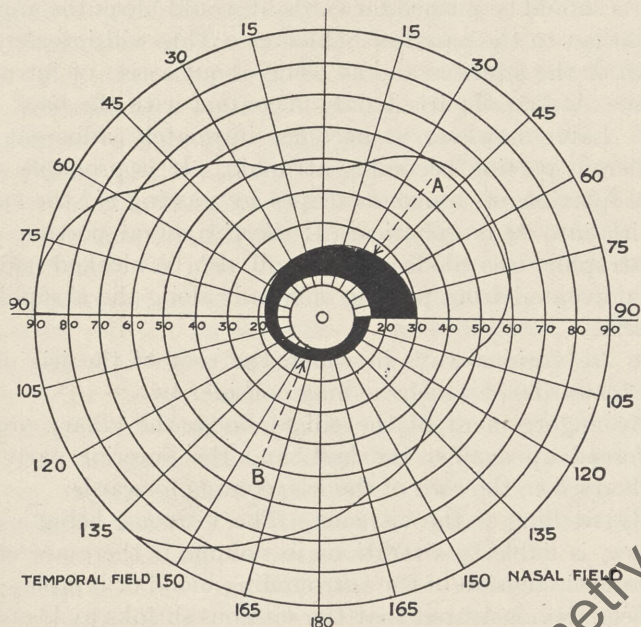


FIG. 141.—Loss of field in left eye, corresponding with lesions shown in Fig. 140. The scotomata originate from the blind spot, which represents the area occupied by the optic nerve. The image produced by the eye is an inverted one, therefore the defect B, in Fig. 140, which is passing from the optic nerve, above the horizontal line and to the left, produces a scotoma below the horizontal line and to the right. Similar reasoning applies to A. The position of the blind spot is just below the horizontal meridian, on the left side, between the 10° and 20° circles.

The small circle in the centre represents the position of the fovea.

It may also occur in glaucoma of long standing in adults, when equatorial staphylomata develop.

(12) The *lens* depends on the aqueous for its nutrition. In glaucoma the flow of aqueous is interfered with, so that a varying degree of cataract may develop.

Having described the effects of increased intraocular pressure, we may now consider the various types of glaucoma in more detail.



## PRIMARY GLAUCOMA

**Ætiology.**—The condition is due to diminished outflow rather than increased secretion of aqueous. This fluid emanates from the ciliary epithelium. It passes forwards through the circumlental space to reach the angle of the anterior chamber, and escape into the canal of Schlemm through the openings in the pectinate ligament (*vide* Frontispiece). If for any reason the peripheral portion of the iris should be pushed forwards, it would block the angle and so the access to the canal of Schlemm. This will interfere with filtration of the aqueous and so bring about a rise of intraocular pressure. At first the iris is only in contact with the back of the cornea. Later, however, it becomes intimately adherent to it, the adherent portion becoming atrophic. It is probable that a small proportion of aqueous escapes by passing *vid* the stomata of the iris into its lymphatics. If the peripheral portion of the iris is atrophic, this mode of exit will also be blocked, since the fluid is prevented from passing outwards along the atrophic root of the iris.

There are various ways in which the root of the iris may be pushed forwards, of which we may consider two :—

(1) By engorgement of the ciliary body, the ciliary processes being forced up against the lens, and the anterior part of the ciliary body, *i.e.*, the root of the iris, coming forwards.

(2) By swelling of the vitreous. The vitreous, being a colloid substance, is liable to alterations in volume if there are changes in the osmotic tension of the surrounding blood or lymph. Thus, it has been demonstrated that the vitreous shrinks by loss of fluid if the osmotic tension of the blood be raised, and the converse is also true. The effect of the acidity or alkalinity of the blood is also a factor in determining the volume of the vitreous. If the vitreous swells, it pushes the lens and iris forwards, thus blocking the outflow of aqueous.

In addition to these two exciting factors there are also two predisposing conditions :—

(1) The size of the eye. It is obvious that the smaller the eye (*i.e.*, the more hypermetropic), the sooner will it be affected by the changes mentioned.

(2) The size of the lens. It is again obvious that the larger the lens, the more likely is the iris to come forwards. It is for this reason that glaucoma is more common in old age, since the lens continues to grow throughout life. It is also common in women at the menopause, because of the vaso-motor instability present at



this period, which may lead to sudden engorgement of the ciliary body. For the same reason, sudden fright or excitement may lead to an attack.

From the clinical point of view there are two types of primary glaucoma—congestive and non-congestive. The former is seen when the rise of intraocular pressure is sufficiently sudden and marked to cause vascular engorgement, the latter when the rise in pressure is gradual and keeps within narrow limits.

(A) **Congestive Glaucoma.**—(1) *Prodromal stage*, or early glaucoma. This stage consists of a series of mild attacks of glaucoma, in the intervals between which the eye may become normal. At first the intervals are quite long (weeks or even months), but later the frequency of the attacks increases. If the eye be examined during an attack, the cornea will be found somewhat hazy from oedema, the anterior chamber shallow, the pupil a little dilated, and there may or may not be some circumcorneal injection. Usually, however, the patient is not seen during an attack, and one has to rely on an account of the symptoms, which are as follows: Cloudy vision, a rainbow halo round lights, a feeling of fulness in the eye and some headache, usually frontal. The attack may last several hours, after which the eye becomes normal again both in appearance and function. It may be precipitated by worry, excitement, indigestion, etc., or, in other cases, may show a remarkable periodicity without any cause. It is usual for the attack to cease during the course of the night.

Diagnosis is often very difficult. The most important points are the occurrence of rainbow haloes associated with a dull pain in the eyes, and, in cases when this stage has lasted for some time, the occurrence of premature presbyopia. With regard to haloes:—

(1) A temporary halo may be present in conjunctivitis when a flake of mucus is on the cornea. This type of halo disappears, however, after winking the eyes and dislodging the flake.

(2) A relatively permanent halo may be present when there are fine opacities in the vitreous (choroiditis or cyclitis).

(3) A permanent halo may occur in the presence of very fine lens opacities—too fine sometimes to be seen by the ordinary means of examination.

Diagnosis is, of course, much simpler if the patient can be made to present himself during a period of misty vision, when the signs mentioned above will be found. Failing this, he should be given pilocarpine  $\frac{1}{2}$  per cent. or eserine  $\frac{1}{4}$  per cent. to



drop into the eye at the next attack. If this procedure completely relieves his symptoms in ten to fifteen minutes it is almost pathognomonic of early glaucoma.

(2) *Stage of Evolution*.—After the prodromal stage has lasted for a variable period, or sometimes without any prodromata at all, there occurs an attack of congestive glaucoma. It may be due to any of the causes which bring about the prodromata, or it may have been caused by dilatation of the pupil. It is important for this reason to estimate the intraocular pressure before instilling a mydriatic in anyone over the age of thirty-five. In cases of doubt homatropine should be used as it can be neutralised by eserine, whereas atropine cannot.

**SYMPTOMS**.—The patient complains of violent pain along the first and second branches of the fifth nerve, which frequently causes vomiting and a rise of temperature. There is great diminution of vision.

**SIGNS**.—There is marked venous congestion and œdema of the conjunctiva, and the lids may be swollen. The cornea is hazy and more or less anæsthetic, the anterior chamber shallow; the pupil, which is inactive and semidilated, is usually oval, the long axis being vertical. The intraocular pressure is raised and the eye may feel as hard as a stone.

**COURSE**.—If untreated, this state of affairs lasts for a period of some days or weeks. An apparent improvement then sets in, the cornea clears, the tension decreases, and the patient regains a certain amount of vision, though there is always some permanent damage to the eye. The quiescent period may last quite a long time before a second attack occurs. When this comes the congestive symptoms are less marked, but there is a further deterioration of vision. Eventually, as a result of repeated attacks, blindness sets in and the eye enters the stage of—

(3) *Absolute Glaucoma*.—The eye is as hard as a stone, the sclera of a bluish-white colour. The cornea, clear and insensitive, is surrounded by the distended anterior ciliary veins. The iris is a dirty grey colour, the pupil widely dilated and the optic disc deeply cupped.

Later still degenerative changes set in. The cornea may ulcerate and the eye develop panophthalmitis from perforation of the ulcer. On the other hand, calcareous bands may form or bullous keratitis develop. The lens becomes opaque and the sclera gradually stretches in the equatorial region, to form dark-coloured prominences. Eventually the blind eye becomes soft



and will shrink owing to atrophy of the ciliary epithelium and non-formation of aqueous.

(B) **Non-congestive glaucoma**, in its early stages, is one of the most insidious forms of eye disease. The increase of tension sets in very gradually, and the patient may be unaware of there being anything wrong until considerable and irreparable damage has been done to the eye.

**SYMPTOMS.**—The patient may complain only of gradual diminution of sight. Frequently, however, he has temporary attacks of blurred vision without any congestive phenomena, unless, as sometimes happens, the disease passes over into the congestive form.

**SIGNS.**—The anterior ciliary veins may be somewhat dilated. The anterior chamber is shallow, the pupil often larger than normal and sluggish in its reaction. The intraocular pressure is slightly above normal, but the cornea is usually clear. For directions for estimation of ocular tension see p. 12.

With the ophthalmoscope, there will be seen a varying amount of cupping of the disc. In the early stages the cupping may be so slight as to be indistinguishable from that normally present as the physiological pit. In advanced cases, the cup may involve the whole disc and have a definite overhanging margin all round. Pulsation of the retinal arteries may also be seen. The fields of vision and the blind spots should be carefully examined, when some of the defects already mentioned will be found (see pp. 210, 211).

**Treatment.**—(1) *Congestive Glaucoma.*—The patient should be sent to bed and given a sharp purge. Hot fomentations, frequently renewed, should be applied to the eye, and two or more leeches to the temple. Eserine 1 per cent. in castor oil should be dropped into the eye every half-hour for two hours, and then used two-hourly. It is well to put a drop into the unaffected eye in case it too should develop glaucoma. The following procedure has recently been advocated, and has proved highly successful for the reduction of tension. The good effect, however, does not last more than about twenty-four hours. The procedure consists in intravenous injection of 50 c.c. of 30 per cent. saline, given by a funnel and tube over a period of ten minutes. Caution must be exercised, however, in old people, as a considerable increase of blood pressure also occurs. Iridectomy—under a general anæsthetic—is the operation of choice in this disease. It is not usually advisable to perform it at



once, as the sudden reduction of pressure may result in a large intraocular hæmorrhage, with loss of the eye. It is therefore advisable to delay operation until the treatment mentioned above has been carried out for a period of twelve to twenty-four hours.

(2) *Non-congestive Glaucoma*.—The treatment here may be myotic or operative. Myotics act by causing contraction of the pupil and thus drawing the periphery of the iris away from the angle of the anterior chamber. They also increase the absorbing surface of the iris. In mild cases it may suffice to employ pilocarpine nitrate  $\frac{1}{2}$  per cent., one drop being instilled into the eye at night. In more severe cases eserine,  $\frac{1}{4}$  to 1 per cent., should be used, the frequency of instillation depending on the severity of the condition. In order to decide whether operation is necessary the patient must be watched with regard to four factors: Visual acuity, intraocular tension, the state of the fields of vision, and the amount of cupping of the disc. If in spite of myotic treatment there is deterioration in any of these, operation is indicated if the eye is to be saved.

Numerous operations have been devised for this purpose, the one most generally used being sclero-corneal trephining (see p. 273).

**Buphthalmos.**—If increased intraocular pressure develops in an infant it causes a uniform distension of the cornea and sclera. This produces a general enlargement of the eye so that it comes to resemble the eye of an ox, hence the name buphthalmos. The condition is easily diagnosed. It is frequently associated with the presence of deep striæ in the cornea due to rents in Descemet's membrane. It is usually bilateral and may be congenital or appear during the first year of life. If untreated it results in blindness.

**ÆTIOLOGY.**—The congenital cases are due to maldevelopment of the canal of Schlemm or of the pectinate ligament. The infantile cases are generally due to peripheral synechiæ.

**TREATMENT.**—The operation of sclero-corneal trephining holds out the best hope of recovery. It may have to be repeated several times on account of the tendency for the hole to be closed by proliferation of the sclera.

## SECONDARY GLAUCOMA

This is due to a multitude of causes, which are best classified by considering the various structures of the eye from the front to the back.



(1) *The Cornea*.—Perforating wounds or ulcers. These usually cause iris adhesions, which result in this membrane being dragged forwards and obliterating the angle of the anterior chamber. If the iris is not entangled, the perforation may remain open for some time (fistula of the cornea), during which the anterior chamber is abolished and the iris is in contact with the back of the cornea. A permanent adhesion may result, so that when the wound heals glaucoma ensues. Glaucoma may be brought about by the entrance of micro-organisms and the occurrence of traumatic iridocyclitis. A fourth way is by the downgrowth of epithelium into the wound. These cells may eventually line the whole anterior chamber and so prevent filtration.

(2) *The Aqueous*.—If the viscosity of this fluid is increased, filtration is interfered with and a rise of tension is produced. Such an increase takes place (a) in certain cases of iritis and cyclitis where fibrinous material is poured out into the anterior chamber; (b) as a result of solution of lens protein, set free by a wound of the lens capsule, traumatic or operative; (c) in thrombosis of the central vein of the retina, in which venous congestion causes a great increase in the albuminous content of the aqueous.

(3) *Iris and Ciliary Body*.—The effect of anterior synechiæ has already been mentioned. Posterior synechiæ, especially if they constitute a complete ring synechia, prevent the forward passage of aqueous and result in iris bombé. New growths of the root of the iris and of the ciliary body may block part of the angle of the anterior chamber.

(4) *Lens*.—The effect of wounds has been mentioned. Glaucoma may occur in intumescent cataract, owing to the swollen lens pushing the iris forwards. It is also seen in dislocation of the lens, particularly when the latter comes forward into the anterior chamber, though lateral and posterior dislocations may also produce the condition.

(5) *Vitreous*.—Large intraocular hæmorrhages may bring about a rise of pressure both by increasing the volume of the ocular contents and by pressing the iris forwards so as to obstruct drainage.

(6) *Choroid*.—New growths (melanotic sarcoma) may act in the same way. Sometimes quite a small growth may produce glaucoma, presumably by interference with venous return.

(7) *Retina*.—The effect of massive hæmorrhages has been mentioned. Glioma of the retina or neuro-epithelioma, if untreated, almost invariably causes secondary glaucoma.

Treatment is necessarily that of the cause.



## CHAPTER XIII

### EXTRINSIC MUSCLES, PARALYSIS, SQUINT

The **extrinsic muscles of the eyeball** are six in number, and comprise the four recti, superior, inferior, internal and external, and the two obliques, superior and inferior. The external rectus derives its nerve supply from the sixth cranial nerve, the superior oblique from the fourth, while the remainder are supplied by branches of the third nerve.

The *levator palpebræ superioris* derives its nerve supply from the third nerve and from the sympathetic. The *recti*, *levator palpebræ* and the *superior oblique* arise from a short tendinous tube, the annulus of Zinn, which is implanted on the apex of the orbit in such a way as to embrace the optic foramen and medial end of the sphenoidal fissure. The base of the annulus is intimately related with the dura mater, since this membrane extends through the apertures of the orbit to become continuous with the orbital periosteum and the sheath of the optic nerve.

The *inferior oblique* arises from the medial side of the floor of the orbit just behind its anterior margin and lateral to the nasolacrymal canal. The recti are inserted into the sclera at a varying distance from the limbus, the mean measurements being : Internal rectus 5.5 mm., inferior rectus 6.5 mm., external rectus 7 mm., superior rectus 7.5 mm.

**The action of the muscles** is as follows :—

(1) The *levator palpebræ* raises the upper lid—the portion supplied by the third nerve brings about voluntary movements, while that supplied by the sympathetic maintains a tonic contraction whereby the eyes are kept open during waking hours.

(2) The *external rectus* is an abductor.

(3) The *internal rectus* is an adductor.

The actions of the four remaining muscles are more complex, and are best considered under two headings, principal and subsidiary. The principal action is at a maximum when the eye is looking along the line of action of the muscle under consideration. The subsidiary action is at a maximum when the eye is looking



along a line at right angles to the line of action of the muscle. Reference to Fig. 142 will show that—

(4) The *superior rectus* passes from the back of the orbit forwards and outwards. Its principal action is therefore at a maximum when the eye is abducted (Fig. 142, *b*) and consists in elevation. On the other hand, when the eye is adducted (Fig. 142, *c*) its attachment is swung over to the inner side of the centre of rotation of the eye, and contraction of the muscle must obviously result in further adduction of the eye. In addition, a resolved portion of the force exerted by the muscle acts in a direction

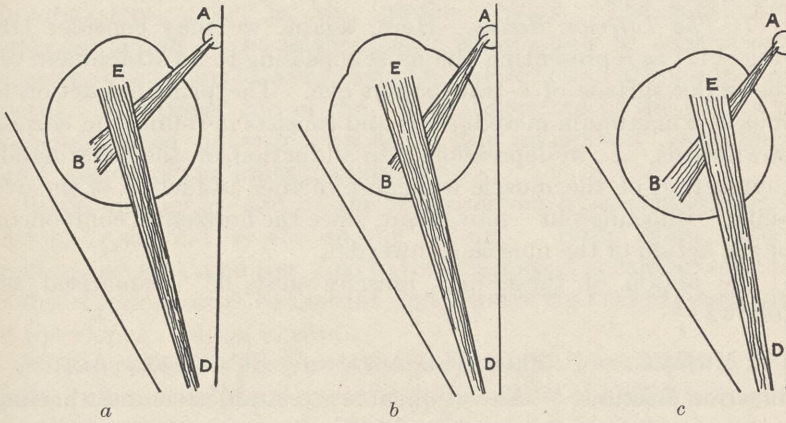


FIG. 142.—Left eye. AB, superior oblique; DE, superior rectus. *a*, looking straight ahead; *b*, abducted, *c*, adducted.

towards the nose, so that the eye will roll inwards around an antero-posterior axis. This is known as “wheel motion.”

(5) *The Superior Oblique*.—Figs. 142 *a, b* and *c* show the reflected tendon of this muscle passing backwards and outwards to be inserted behind the centre of rotation of the eye and a little to the outer side of the superior rectus. The principal action is thus at a maximum in adduction and must consist in turning the cornea downwards, since the muscle is inserted behind the centre of rotation of the eye. For the same reason, when the eye is abducted, contraction of the muscle must cause a further increase in abduction and a “wheeling-in” motion, since the top of the eye is being dragged over towards the nose.

(6) *The Inferior Oblique*.—For all practical purposes, this muscle may be considered as occupying a position on the under-surface of the globe, similar to that occupied by the reflected tendon of the superior oblique on the upper surface. Its actions may therefore



be elucidated with the aid of Figs. 142, *a*, *b* and *c*, if we imagine that the eye is transparent, and that AB represents the inferior oblique passing to its attachment on the under-surface of the eye. It will now be seen that the principal action is at its maximum when the eye is adducted and that it consists in elevation, since the muscle is inserted behind the centre of rotation of the globe. In the same way, it will be seen that in abduction, shortening of the muscle results in a further increase of this movement. Also, since the lower surface of the eye is being dragged in towards the nose, there will be a wheel motion as though the eye were being rolled outwards.

(7) *The Inferior Rectus*.—Here, again, we may consider DE (Fig. 142) as representing the muscle passing to its attachment on the under-surface of a transparent eye. The principal action is thus at a maximum in abduction and consists in rolling the cornea downwards, *i.e.*, in depression. In adduction, on the other hand, contraction of the muscle will cause further adduction of the eye and a “wheeling-out” movement, since the horizontal component of the action of the muscle is inwards.

The action of these four muscles may be summarised as follows :—

MUSCLE.	PRINCIPAL ACTION.	SUBSIDIARY ACTION.
<b>Superior Rectus.</b>	Elevation, at a maximum in abduction.	Adduction and wheeling in, at a maximum in adduction.
<b>Superior Oblique.</b>	Depression, at a maximum in adduction.	Abduction and wheeling in, at a maximum in abduction.
<b>Inferior Oblique.</b>	Elevation, at a maximum in adduction.	Abduction and wheeling out, at a maximum in abduction.
<b>Inferior Rectus.</b>	Depression, at a maximum in abduction.	Adduction and wheeling out, at a maximum in adduction.

From a consideration of these actions, it will be seen that several muscles are concerned in the various movements of the eye. Thus in—

(1) *Abduction*.—The eye is carried outwards by the external rectus, assisted towards the end of its course by the two oblique muscles, whose torsional and vertical effects neutralise each other.



(2) *Adduction*.—The eye is carried inwards by the internal rectus, assisted towards the end of its course by the superior and inferior recti. Here, again, the vertical and torsional effects neutralise each other.

(3) *Elevation*.—The eye is carried straight upwards by the combined actions of the superior rectus and inferior oblique. The subsidiary actions of these two muscles neutralise one another, so that the vertical meridian of the cornea remains vertical and there is no adduction or abduction. It is probable that the external and internal recti also act to steady the eye.

When looking up and out, the eye is moved by the superior and external recti, aided by the inferior oblique. The subsidiary torsional action of the latter muscle cannot now be neutralised, since the eye is now looking along the line of action of the superior rectus. The upper end of the vertical meridian of the cornea is therefore tilted outwards, owing to the unopposed "wheeling-out" action of the inferior oblique.

When looking up and in, the eye is moved by the superior and internal recti and by the inferior oblique. Here, again, wheel motion becomes manifest, due to the unopposed subsidiary action of the superior rectus, so that the upper end of the vertical meridian of the cornea is tilted inwards.

(4) *Depression*.—The eye is carried straight downwards by the inferior rectus and the superior oblique, whose subsidiary actions neutralise one another, so that there is no wheel motion, adduction or abduction. As in elevation, the internal and external recti probably help to steady the eye.

On looking down and out, there is an unopposed "wheeling-in" motion due to the action of the superior oblique, so that the vertical meridian of the cornea is tilted inwards.

On looking down and in, the unopposed torsional effect of the inferior rectus causes the vertical meridian of the cornea to be tilted outwards.

### PARALYSIS OF THE OCULAR MUSCLES

Paralysis may be brought about by a large variety of lesions acting on any part of the oculo-motor apparatus from the cerebral cortex, down to the actual muscles themselves.

**SIGNS AND SYMPTOMS.**—These are best understood if we consider first what happens in paralysis or paresis of a single muscle, e.g., the right external rectus. There will be :—

(i.) **Abolition or diminution in movement** of the right eye outwards beyond the middle line.



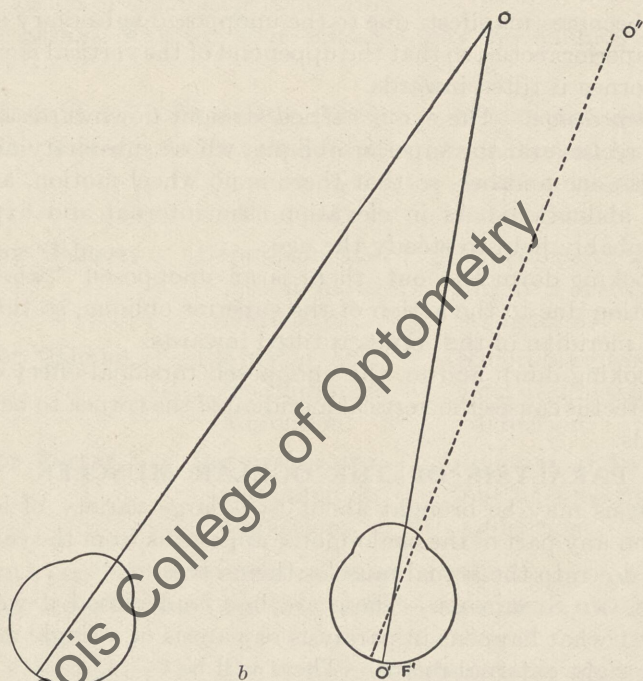
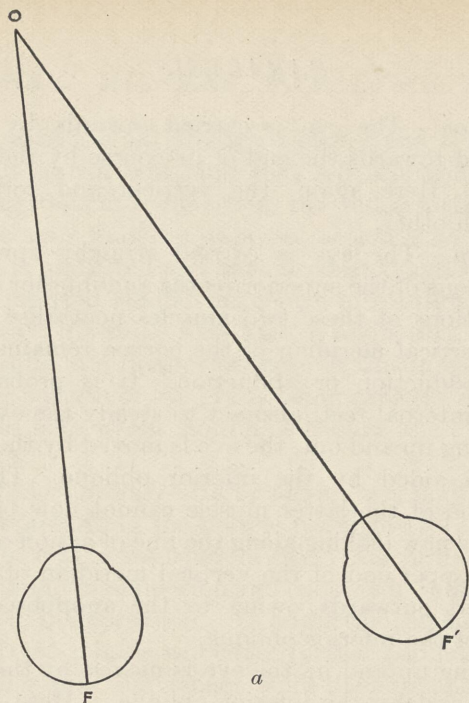


FIG. 144. Case of right external rectus palsy. *a*, Both eyes looking at O, to left of middle line image formed at foveæ (F and F') in both eyes. *b*, Both eyes attempting to look at O, to right of mid-line, image in left eye on fovea F in right eye to nasal side of fovea F' at O'.



(ii.) **Diplopia**, elicited on looking to the right. In order to understand how this occurs, reference should be made to Fig. 143, *a* and *b*. In Fig. 143, *a*, both eyes are directed towards an object *O* placed a little to the left of the midline and the image of *O* falls on *F* and *F'*, the foveæ of the two eyes, so that it is seen as a single object. In Fig. 143, *b*, *O* is placed to the right of the middle line, and both eyes are attempting to look at it. In the left eye, the image falls on the fovea, but in the right it falls on *O'* to the nasal side of it. Now, the patient is unaware that his right eye is looking straight forward, and imagines that it is also turned to the right. If the eye were really in this position, the fovea would be at *O'* and an object which formed a retinal image to the left of it would have to be at *O''*, so that this represents the position to which the patient projects the image

of *O* formed by the right eye. In other words, the false image appears to move in the direction of action of the paralysed muscle (*i.e.*, if the muscle cannot move the eye, it moves the image). This is true of all the extrinsic muscles of the eye, so that, once we know their action, the resulting diplopia can be deduced. Take, for example, the right superior oblique. The principal action of this muscle is to depress the eye,

R	R	R
$\overline{R}$	$\overline{R}$	$\overline{R}$
$\frac{L}{R}$	$\frac{L}{R}$	L R

FIG. 144.—Diplopia produced by paresis of right superior oblique muscle.

the action being at a maximum in adduction; its secondary action of abduction and "wheeling in" is at a maximum in abduction. The resulting diplopia would therefore be as indicated in Fig. 144, where there is a vertical separation of images on looking down to the left, the lower image belonging to the paretic right eye; and a horizontal separation on looking down and to the right, the image on the right belonging to the right eye. In order to obtain a diplopia chart, the patient is fitted with a pair of red-and-green goggles, the red glass being placed in front of the right eye. He is placed in a darkened room, and a lighted candle is held in front of him and moved into the various positions indicated in Fig. 144, up, down, up and out, down and in, etc. He is then asked if he sees a double image in any position, and if so, the relative positions of the red and green candle flames.

Assuming now that we have obtained a chart such as that in Fig. 144 it could be worked out as follows:—

- (1) The muscle at fault is a depressor, since diplopia is evident



only on looking down, *i.e.*, it is an inferior rectus or superior oblique.

(2) The right eye is affected, since the right image is the more displaced (the muscle moves the image and not the eye).

(3) The affected muscle is one which acts as a depressor when the eye is adducted, and as an abductor when the eye is abducted, *i.e.*, it is the right superior oblique.

Similar reasoning may be applied to paralysis of other muscles. The student should attempt to work out which muscle, when paralysed, would produce the diplopia shown in Fig. 145. The answer is given at the end of the index.

(iii.) In order to obtain single vision, the patient moves his head in the direction of action of the paralysed muscle, *e.g.*, if it were the right external rectus, the head would be turned to the right.

L R	L R	RL
L̂ R̂	L̂ R̂	RL
R R	R R	R

FIG. 145.—Diplopia chart, to work out, answer at end of index.

(iv.) **False Projection.**—The best way to test for this is to give the patient a piece of cardboard about 14 by 10 inches, with a mark at one end of it. The mark is placed towards the side of the palsied muscle (*e.g.*, to the right of the midline for a palsied right external rectus). He is instructed to hold this

cardboard against the upper lip, and, with one or other eye closed, attempt to move a pencil along its lower surface, so that it shall emerge opposite the mark. In the case of paralysis of the right external rectus, it will be found that with the right eye closed the attempt is fairly accurate, whereas if the left eye be closed, the pencil emerges to the right of the mark, *i.e.*, there is false projection—again in the direction of action of the paralysed muscle. If the affected muscle be an elevator or depressor, the board should be held vertically on one or other side of the nose. The reason why this false projection occurs is that the patient is sending such a strong impulse down the nerve to the affected muscle that he imagines it to be far more contracted than it really is.

(v.) **The secondary deviation exceeds the primary.** Suppose again that there is a partial paralysis of the right external rectus. If the right eye be covered with a card and the patient directed to look at an object on the right, the left eye will be directed towards it, whereas the right eye will lag behind, and there will then be a certain (primary) deviation of the right eye. If now the left



eye be covered and the patient be directed to look at the same object, the right eye may, by a great effort, be made to turn outwards and fix it. This excessive effort will also be communicated to the left internal rectus, so that the left eye will move too far inwards. The deviation of the left eye thus produced is known as secondary deviation, and its amount is in excess of the primary deviation. In concomitant (*i.e.*, non-paralytic squint) these two deviations are equal.

(vi.) **Vertigo**, due to the diplopia and false projection.

(vii.) The diplopia and deviation **increase as the eye is moved in the direction of action of the paralysed muscle.**

DIFFICULTIES IN INTERPRETATION OF SIGNS AND SYMPTOMS.—

(1) More than one muscle may be involved, and the paresis may be binocular. In these cases an anomalous type of diplopia chart is obtained, and careful observation of the movements of the two eyes is essential.

(2) In extreme positions of lateral movement the vision of the sound eye may be cut off by the nose, and the paretic eye take on fixation. There is thus a sudden movement in the sound eye representing the difference between primary and secondary deviation.

(3) The condition may be one of spasm of a muscle (*e.g.*, the left internal rectus) rather than paralysis of its associate (the right external rectus). This is a rare condition, and difficult to diagnose. The main point is that the excursion of the faster moving eye is greater than normal, while that of the slower moving eye is normal and not subnormal, as in paralytic cases.

(4) A previously latent "phoria" may become manifest, *e.g.*, in paralysis of an elevator, binocular fusion of images is impossible when the patient is looking up. If, at the same time, he has exophoria, the eyes will also diverge on looking up, whereas on looking down the exophoria is kept in check by his fusion sense. The effect of this is not very serious, however, as the amount of (say) divergence, when it appears, is constant in different parts of the field.

(5) In traumatic cases, *e.g.* hæmorrhage into the external rectus muscle sheath, with subsequent degeneration, there is loss of normal movement, both in abduction and adduction, owing to cicatricial shortening.

**ETIOLOGY.**—The causes of ocular palsies are very numerous and may be grouped as follows :—

(1) **Congenital.**—Aplasia of a muscle.



(2) **Traumatic.**—Hæmorrhage into the muscle sheath, division of a muscle by a penetrating injury, fracture of the base of the skull involving nerve injury, exposure to cold.

(3) **Inflammatory.**—This group is best considered under four headings :—

(a) *Inflammation proper.*—Basal meningitis, formation of gummata or of tuberculous masses, lethargic encephalitis, peripheral neuritis.

(b) *Vascular.*—Hæmorrhage, thrombosis, embolism, pressure or rupture of aneurysms, pressure of sclerosed arteries.

(c) *Toxic.*—Alcohol, lead, botulism, diphtheria and influenza.

(d) Where the palsy forms *part of some more general disease*, e.g., tabes, general paralysis, disseminated sclerosis, syringomyelia, postero-lateral sclerosis, paralysis agitans, progressive muscular atrophy and myasthenia gravis.

(4) **Neoplastic.**—Glioma, endothelioma, etc., while in a certain number of cases the ætiology is unknown.

**With regard to site**, the lesion may be :

(1) *Cerebral.*

(a) Supranuclear : cortical and subcortical.

(b) Internuclear.

(c) Nuclear or radicular (*i.e.*, involving the nerve root).

(2) *Extra cerebral.*

(a) Intracranial.

(b) Intraorbital.

(3) *In the muscle.*

If the lesion is above the nuclei, it causes paralysis of a group of muscles and not of a single muscle, *i.e.* if there be involvement of only one muscle, the lesion must be nuclear or infranuclear. The only exception to this occurs in the case of ptosis, which may be due to a cortical lesion.

*Cortical and Subcortical Lesions.*—The following centres are described :—

(1) The second frontal gyrus. Stimulation of this region causes conjugate movement of the head and eyes to the opposite side, but no purely vertical movement. Abolition of this centre causes loss of voluntary movement in a given direction, but not of reflex movements of the eyes.

(2) The angular gyrus. Lesions of this area in man fail to produce any actual palsy, though there is often some manifestation of ocular apraxia, *i.e.*, there is failure to obey an order to turn the eyes in any special direction.



(3) The occipital lobe. This includes the visual area of the cortex, in which are represented the various parts of the retina. If a certain part of the cortex be stimulated—corresponding, say, with the right inferior portion of the field of vision—it will give rise to a sensation of light proceeding from this part of the field, *i.e.*, downwards and to the right. The eyes will then move downwards and to the right so as to bring the supposed light on to the fovea. The occipital cortex is therefore to be regarded as the centre for regulating reflex responses of the eyes to visual stimuli, *e.g.*, the sort of movement which occurs when the eyes are following an object moving to the right, as opposed to the sort of movement which occurs when the patient is told deliberately to look to the right. In this way we may explain the deviation of the eyes to the seeing side in cases of hemianopia.

*Supranuclear Centres.*—Those for conjugate lateral movements are in all probability close to the nucleus of the sixth nerve, which lies under the grey matter of the floor of the fourth ventricle. The supranuclear centres for convergence and conjugate vertical movements are possibly in the anterior corpora quadrigemina, though their exact site has not yet been determined.

The centres for lateral movements receive all stimuli which can excite conjugate movements of the eyes to the same side, *e.g.* :—

- (i.) From the cortex.
  - (a) Voluntary impulses from the opposite frontal centre.
  - (b) Impulses from the occipital and temporal cortex, bringing about adjustment of the eyes to visual and auditory stimuli.
- (ii.) From the lower visual and auditory centres in the mid-brain.
- (iii.) From the labyrinth *via* Deiter's nucleus.
- (iv.) Proprioceptive impulses from the muscles of the neck.

A lesion involving the supranuclear centres will therefore cause paralysis of the associated movements of the eyes in some given direction, while one involving the fibres passing to them may cause loss of response to certain stimuli, and not to others. Lesions of the lateral portion of the pons, for instance, may abolish reflex movements of the eyes to labyrinthine stimuli, though the eyes may move normally to volitional and other impulses.

The *nuclei* of the third, fourth and sixth nerves are found respectively (i.) in the grey matter surrounding the ventral part of the Sylvian aqueduct; (ii.) subjacent to the anterior corpus



quadrigeminum ; (iii.) in the grey matter subjacent to the floor of the fourth ventricle. The nuclei are connected by an important tract of fibres, the posterior longitudinal bundle, which also brings them into relation with the supranuclear centres and all their connections, and with the anterior horn cells of the cord. One of the functions of this bundle is to bring the action of the external rectus of one eye into association with the internal rectus of the other eye.

In consequence of this, it is possible to localise lesions in this area with a considerable degree of accuracy, and four types of syndrome are described.

(a) Weber's. Complete paralysis of one third nerve with hemiplegia of the opposite side, indicates a lesion at the upper end of the pons, or lower end of the crus, which involves the roots of the third nerve on their way out and the pyramidal fibres.

(b) Benedict's. Third nerve paralysis on one side with tremors and convulsive movements of the opposite arm and leg. The lesion is deeper in the mid-brain, involving the red nucleus and the root fibres of the third nerve as they pass through it or beside it.

(c) Foville's. Due to a lesion of the sixth nerve nucleus ; produces paralysis of the homolateral external rectus and facial muscles, with contralateral hemianæsthesia from involvement of the mesial fillet and the spino-thalamic tract. In addition there is paralysis of the opposite internal rectus in conjugate deviation, but not in convergence. This is because the fibres of the posterior longitudinal bundle are interrupted, so that there is no longer any connection between the nuclei supplying the external rectus of one side and the internal rectus of the other.

(d) Millard-Gubler. Complete paralysis of the sixth and seventh on one side, with crossed hemiplegia, but no affection of the opposite internal rectus. In these cases the lesion is near the lower end of the pons, and involves the sixth nerve root, but not the nucleus, so that the posterior longitudinal bundle is still functional.

*Basal Affections.* Paralyses due to lesions of the base of the brain—meningitis, fractures, etc.—as a rule affect several nerves, and often both sides at once. If the paralysis is monocular, and is associated with loss of sight in the affected eye without ophthalmoscopic changes or loss of sight in the fellow eye, it indicates a lesion of the intracranial or intraorbital part of the nerve.



Solitary abducens paralysis is not uncommon in fractures of the base of the skull, being due to a fracture of the petrous bone. The same lesion also occurs as a result of otitis (Gradenigo's syndrome), and a transient form of it after spinal anæsthesia.

*Ophthalmoplegic migraine*—a periodic type of ophthalmoplegia, ushered in by headache and often vomiting—is frequently basal in origin, being caused by the pressure of a basal aneurysm or exudate or small growth on the third nerve. Some of the cases, however, are purely functional.

*Orbital affections* are indicated by the co-existence of other symptoms, such as pain on movement of the eye or on pressure over it, proptosis, unilateral papilloedema or papillitis, evidence or history of orbital trauma.

*Muscular Affections.*—A hereditary type of progressive ophthalmoplegia may occur, usually in adult life, affecting one muscle after the other and due to what is termed "abiotrophy." Myasthenia gravis may also affect the extrinsic eye muscles, the levator palpebræ being most commonly involved. In these cases, the muscular weakness is rapidly increased by exhaustion.

### CONCOMITANT STRABISMUS OR NON-PARALYTIC SQUINT

This is a condition in which the patient uses only one eye for fixation, the other being either convergent or divergent, though there is no ocular palsy. The angle of deviation, therefore, remains the same, whatever the direction in which the patient looks. The following varieties occur :—

- (1) Periodic—in which the squint is not always present. This usually happens in early cases and is of good prognostic import.
- (2) Constant—in which the squint is always present.
- (3) Unilateral—where only one eye squints.
- (4) Alternating—where the squint may occur in either eye, the visual acuity in each eye being approximately the same.
- (5) Convergent.
- (6) Divergent.

**Ætiology**—(i.) **FUSION FACULTY.**—In a normal individual what is known as the "fusion faculty" causes an instinctive tendency to blend the images formed in the two eyes. The eyes do not therefore deviate, and nothing short of actual paralysis or paresis of an extraocular muscle will cause them to do so. Should this occur, the resulting diplopia is almost intolerable. Sometimes, however, the fusion faculty is very weak or does not



develop. This leaves the eyes in a state of unstable equilibrium, so that deviation may occur on the slightest provocation. Such provocation may be supplied by—

(1) *Hypermetropia*, in which the patient has to accommodate to see even distant objects. Since accommodation and convergence are synergic he will also tend to converge, and with a weak fusion faculty this potential convergence may become manifest convergence. Diplopia is not noticed, because—

(a) The image in the squinting eye is formed at some distance from the macula, and is therefore indistinct.

(b) The patient very soon learns to suppress the second image in the interests of clear vision.

(2) *Anisometropia*.—The vision in the two eyes is unequal and the patient elects to use the eye with the clearer vision, the other deviating inwards or outwards.

(3) *Diseases* causing further reduction of fusion faculty. This faculty is one of the highest cerebral functions, and is therefore one of the first to be attacked in diseases causing exhaustion and debility. It is for this reason not uncommon to find the origin of a squint dating from an attack of measles, whooping cough or convulsions.

(4) *Myopia* may bring about a divergent squint, though, contrary to what one would expect, it is sometimes convergent.

(5) *Defective Muscle Balance*.—Apart from any error of refraction the adductors or abductors may be more powerful than their opponents, so that the position of the eyes at rest is respectively convergent or divergent. An extreme case of this anomaly is congenital absence of an external rectus.

(ii.) *DIMINUTION OF VISUAL ACUITY IN ONE EYE*.—Statistics show that retinal or optic nerve hemorrhages occur in quite a considerable proportion of children at birth. The majority clear up and leave no permanent effect. Now and again, however, a more serious lesion occurs at the macula or involves the papillo-macular bundle in the nerve, causing permanent abolition of central vision. In these cases the eye is not used for central fixation and so is free to deviate inwards or outwards. The same thing frequently happens in acquired monocular blindness, *e.g.*, in monocular cataract. In these cases the blind eye nearly always deviates outwards, because the axis of the orbit points forwards and outwards.

*AGE OF ONSET*.—The commonest age is between two and three, though it may be much earlier.



**Diagnosis.**—During the first few months of life both macular fixation and fusion faculty are poorly developed, so that it is quite common for a normal baby to squint occasionally. Should the squint show any signs of persisting, even at this early age, it requires adequate treatment.

In many cases strabismus is quite obvious, but in others, when the deviation is only slight, its detection requires a careful examination, performed as follows. The child is seated in a moderately dark room with a lamp over her head. The examiner, seated at a distance of 2 feet from the child, reflects the light into her eyes with a plane ophthalmoscope mirror. A baby will at once look at the light, and an older patient should be told to do so. The examiner looks over the top of the mirror and notes the position of the corneal reflex in the two eyes, its usual position being slightly to the nasal side of the centre of the pupil, owing to the angle gamma (*vide* p. 41). If the position of the corneal reflex be the same in both eyes they must both be looking in the same direction, *i.e.*, at the reflection of the light in the mirror. If there be, say, a right convergent squint, the reflex in the left eye will be in the normal position, while in the right eye it will be displaced towards the temporal side. If the squint be divergent the displacement is towards the nasal side. A rough estimate of the angle of squint can be obtained by Hirshberg's test: A candle is placed 1 foot in front of the eyes and the patient looks at it, the observer being behind the candle. If the reflex in the squinting eye is at the margin of the cornea the angle is  $45^\circ$ , if at the margin of an average sized pupil it is  $15^\circ$ .

A more accurate method is to use Priestley Smith's tape. The patient puts one of the rings of the tape round her index finger, which she holds against her cheek. The examiner puts the handle of his ophthalmoscope through the outer ring, directing the light from the mirror on to the cornea of the squinting eye, while he looks through the sight hole of the mirror. Then, assuming again that the case is one of right convergent strabismus, he takes the graduated tape between the middle and index fingers of the left hand, which is held level with the mirror. The patient is directed to look at the examiner's fingers, which he moves towards the left, along the tape, until the corneal reflex in the right eye occupies the same position as it did in the left when the latter was looking straight at the mirror. The number on the tape opposite the examiner's fingers will indicate the angle of the squint.



In cases of small degree the asymmetry in the corneal reflex may be very slight. In such cases it is advisable to cover first one eye and then the other, noting whether there is any movement in either eye on covering up the other. In a case of slight right convergent strabismus the left eye will be fixing the mirror, and on covering the right there is no movement. If the left be covered, however, the right eye will move outwards to take up fixation.

*Apparent strabismus* may be caused by two conditions :—

(1) A large angle gamma, which may cause an apparent divergence of the eyes, or a negative angle gamma, which may cause apparent convergence.

(2) Epicanthus, in which a vertical fold of skin is present at the inner canthus. This causes diminution in the amount of exposed sclera on the nasal sides of the corneæ and an appearance resembling convergent squint.

In both of these conditions the mirror test shows symmetry in the position of the corneal reflexes, and so demonstrates the absence of true strabismus.

**Course.**—At first the squint is only occasional and either eye may deviate. Later, however, the squint tends to become constant and to be present always in the same eye.

If untreated, a condition of amblyopia from disuse may develop in the deviating eye. In this condition there is no fundus abnormality, but vision, even with appropriate glasses, cannot be brought up to normal, and is usually only about 6/60 or 6/36. Amblyopia from disuse is usually curable if treated in time, but if the condition has lasted more than half the child's life, or if the child, when first seen, is over the age of six, the prognosis is not good, though occasionally exceptions occur.

**Treatment**—(a) **CONVERGENT SQUINT.**—(1) The first essential is adequate correction of any error of refraction. For this purpose atropine, in the form of drops or ointment, is used three times a day for a period of four days prior to performance of retinoscopy. It should be realised that no child is too young for this to be done, since all children will look at a bright light, and there is usually no difficulty about holding lenses in front of the patient's eye—retinoscopy being done at arm's length. The fixing eye should be covered during the testing of the deviating eye, or the latter will not look at the mirror. Glasses should be ordered in accordance with the rules already laid down (pp. 58, 59). Infants should have them tied on. The child should now be watched for



a period of two months or so, and if the case be an early one the axes of the eyes may become parallel.

(2) If squinting persists, steps must be taken to prevent the development of amblyopia. For this purpose the fixing eye should be covered during waking hours. This is most easily done by means of a piece of cotton wool tucked in behind the glasses with the eye closed. If the child pushes his glasses up, so as to uncover the eye, it may be necessary to hold the pad in place with strapping all round its edges.

In this connection it is, of course, a great help if some estimate can be made of the visual acuity in the squinting eye. If the patient knows her letters, there is no difficulty about it; if not, Worth's ivory ball test may be employed. The balls are five in number and vary in diameter from  $\frac{1}{2}$  inch to  $1\frac{1}{2}$  inches. The child is first allowed to handle the balls with both eyes open, then one eye is covered by a piece of wool behind the glasses. She is then asked to go and pick up the balls as they are thrown on the floor to a distance of 6 or 7 yards, one by one, beginning with the largest. The balls should be thrown with a spin so that they "break" on touching the floor, and the non-squinting eye tested first. A rough estimate of the visual acuity can be made from the size of the smallest ball the child can see.

The child should have the fixing eye covered for three weeks and then be re-examined. If the deviating eye has improved sufficiently the case should be treated as described below; if not, covering should be continued for a further month. If there is no improvement at the end of this time further treatment of the amblyopia is usually hopeless.

(3) Instillation of a drop of 1 per cent. atropine sulphate into the fixing eye every morning has the effect of rendering it useless for near vision, and thus encourages the use of the deviating eye for this purpose, either eye being available for distant vision. After a few weeks or months of this treatment the vision of the deviating eye will, in many cases, approach the normal. Should this occur, the previously squinting eye will be used for fixation. Atropine is now stopped for three weeks to see what will happen. Usually the squint returns to the original eye, and in these cases it is well to order atropine for the fixing eye every morning for the first week of each month. The treatment is continued until the vision in the two eyes is approximately equal, or until no further improvement is obtained in the squinting eye.

Equality of vision in the two eyes is usually shown by the



squint becoming alternating, *i.e.*, by the patient continuing to use either eye for fixation after the other has been momentarily covered.

(4) Fusion training may be undertaken when the vision in the two eyes has become approximately equal. The principle involved is to train the child in the use of the two eyes together. It is seldom worth while to begin this training at an earlier age than three or at a later age than six.

Space does not permit of a full description of the methods employed, but they consist essentially in the use of a modified form of stereoscope in which different parts of the same picture are presented to the two eyes, allowance being made for the squint. In this way the child learns to combine the images, so as to produce a single picture and, in favourable cases, to develop stereoscopic vision with abolition of the squint.

(5) Operation becomes necessary if the deviation is not overcome by other means. It must be realised, however, that straightening the eye by operation will not improve its vision. In the majority of cases the effect is purely cosmetic, unless the visual acuity be approximately equal in the two eyes. In the latter case a successful operation may restore binocular vision. If the error of refraction is such as to necessitate the wearing of glasses the operation must be planned accordingly, *e.g.*, in a hypermetropia with a convergent squint, the angle may be  $25^{\circ}$  without glasses and only  $15^{\circ}$  with. In such a case the operation should be planned so as to correct only  $15^{\circ}$  of convergence, not  $25^{\circ}$ , as in the latter case the eyes would be  $10^{\circ}$  divergent when the glasses were worn. For this reason it is well to defer operation until the correcting glasses have been worn for at least six months.

(b) DIVERGENT SQUINT.—(1) Blind divergent eyes are usually best left alone. Operation may produce temporary rectification, but the condition is very apt to recur.

(2) Divergence sometimes occurs as a late result of too free a tenotomy of the internal rectus (*vide* section on Operations, p. 256).

(3) Divergent squint in myopia and myopic astigmatism may disappear when the error of refraction is accurately corrected; if not, operation may be required.

(4) Occasional divergent squint may occur apart from any error of refraction. These cases are often familial and seldom show much improvement under treatment. Occasionally, however, the frequency of the divergence may be diminished by a course of fusion training.



## CHAPTER XIV

### ORBIT

#### ANATOMY

THE bony orbit forms a quadrilateral pyramid, with the apex at the optic foramen and the base bounded by the orbital margin. The medial or nasal wall of the orbit is that by which inflammation most commonly enters from surrounding parts. It is formed chiefly by the lacrymal bone and the orbital plate (os planum) of the ethmoid. The nasal fossæ and the ethmoidal air cells lie mesially to the orbit; the sphenoidal sinus above and behind; the frontal sinus above, to the nasal side, anteriorly; and the maxillary antrum below. The contents of the orbit are the eyeball, which has a diameter in the three directions of slightly less than 2.5 cm., the optic nerve, the extrinsic muscles, the lacrymal gland, blood vessels, nerves, orbital fat and fascia. The capsule of Tenon is the connective tissue which envelops the sclerotic. It is a layer loosely attached to the sclerotic in front, and to the bed of orbital fat posteriorly. Within it the eyeball is free to move to a slight extent. On free excursions of the eyeball the tissue of Tenon's capsule also moves. Recent work fails to reveal any trace of an endothelial lining to the capsule or upon the eyeball (Whitnall). The blood supply of the orbital contents is derived mainly from the ophthalmic branch of the internal carotid. The ophthalmic veins drain into the cavernous sinus. The orbital lymphatics drain into the superior deep cervical lymph glands *via* the internal maxillary nodes. The motor nerves are the third, fourth, and sixth cranial, and the sensory nerves are the ophthalmic nerve and the maxillary nerve (first and second divisions of the fifth cranial). The sympathetic nerve fibres are distributed along the ophthalmic artery from the carotid plexus. The ciliary ganglion lies on the outer surface of the optic nerve. It is formed by the union of branches from the third (motor root), the ophthalmic nerve (sensory root), and sympathetic fibres from the carotid plexus.



### CONGENITAL ABNORMALITIES OF THE EYEBALL

These are rare.

*Anophthalmos* is the absence of an eyeball.

*Microphthalmos* is the condition of mal-development of the eyeball, so that it remains small in all its dimensions.

*Buphthalmos* (congenital glaucoma) is present when the eyeball steadily enlarges owing to a congenital defect of the angle of the anterior chamber and failure of the normal aqueous drainage.

### TRAUMA

Injuries of the orbit include contusions, wounds, hæmorrhage, fracture of the orbital wall, retention of foreign bodies. Marked proptosis occasionally results from hæmorrhage. Surgical emphysema of the orbit or of the upper lid commonly occurs after fractures. Infection by dirty objects produces inflammation in the form of orbital abscess or cellulitis. Periostitis of the orbital margin occasionally follows a contusion. The optic nerve may be severed in penetrating wounds, or by fractures at the optic foramen, with subsequent optic atrophy. Deeply penetrating wounds, as by a bullet, sometimes cause the development of an arterio-venous aneurysm by injury to the cavernous sinus and the carotid artery.

### INFLAMMATIONS AND NEOPLASMS

There are several forms of inflammation in the orbit or its neighbourhood which require careful investigation for their diagnosis. They have several physical signs in common, the most important of which is exophthalmos or proptosis of the eyeball. The various forms of inflammation to which reference is made above are orbital periostitis, orbital cellulitis, thrombosis of the cavernous sinus, and Tenonitis or inflammation of the capsule of Tenon.

**ÆTIOLOGY.**—*Acute orbital periostitis* occurs as the result of contusion of the bony margin of the orbit, or by extension of inflammation from any of the accessory nasal sinuses, particularly the ethmoid cells. Periostitis of a more *chronic* form results from local tuberculosis in children, and from tertiary syphilis in adults. The latter is usually a hypertrophic periostitis, and shows thickening of the bone.

*Orbital cellulitis* may follow periostitis or wounds with the introduction of septic material or foreign bodies. It may also



occur by extension of inflammation from the accessory sinuses, and from erysipelas of the face. Finally, it may be metastatic in origin, as a blood-borne infection in pyæmia, septicæmia or in some acute fevers.

*Cavernous sinus thrombosis* is an infective thrombosis which occurs (1) by local extension along veins infected from an orbital abscess, the result of periostitis or cellulitis; from sepsis in the nose or its accessory sinuses, from the tonsils, the teeth, or from caries of the petrous bone, or from erysipelas of the face. In all these areas the infection is carried by veins draining the septic area and communicating with the cavernous sinus. *Viâ* the orbit, the channel is by the ophthalmic veins, from the petrous bone *viâ* the petrosal sinus. (2) Metastatic infection, in pyæmia, septicæmia or specific fevers.

*Tenonitis* is a non-suppurative inflammation of the capsule of Tenon, and follows panophthalmitis (see p. 155) or infected wounds which penetrate the capsule, or occurs in gout or rheumatism, or as the result of a chill.

**SYMPTOMS, PHYSICAL SIGNS AND DIAGNOSIS.**—For convenience of comparison the symptoms and signs of these inflammatory conditions are arranged in tabular form beside those of neoplasms of the orbit.

In all cases of proptosis, in the absence of other definite evidence which might confirm the diagnosis, the nose, throat, ears and teeth should be examined, and transillumination of the accessory nasal sinuses should be carried out. By these means proof may be forthcoming of the presence of a neighbouring focus of sepsis. The Wassermann reaction should be carried out, and if it be positive, anti-syphilitic treatment should be employed. The possibility of the presence of early Graves' disease should be borne in mind, even when proptosis affects only one eye.

**TREATMENT OF INFLAMMATIONS OF THE ORBIT.**—(1) *General Treatment.*—In the presence of tuberculosis the usual hygienic measures should be adopted. If syphilis be suspected as the cause of periostitis, medication with mercury and iodides and an arsenic preparation should be employed. Purging and diaphoresis are advisable in cases of septic origin.

(2) Any source of sepsis in teeth, ear, throat, nose or accessory sinuses should be treated. A foreign body in the orbit should be removed, and septic wounds should be drained freely. The cause of a pyæmia or septicæmia should already be under treatment.



	PERIOSTITIS, EXCLUDING CHRONIC FORMS.	CELLULITIS.	CAVERNOUS SINUS THROMBOSIS.	TENONITIS.	NEOPLASMS, OSTEOOMA, CAVERNOUS ANGIOOMA, LACRYMAL GLAND TUMOUR, SARCOMA.
History of onset . . .	Sudden . . .	Sudden . . .	Sudden . . .	Sudden . . .	Gradual.
General condition {	Malaise . . .	Malaise . . .	Extreme malaise . . .	Slight malaise . . .	Normal, apart from cachexia from large malignant growths.
Pyrexia . . .	Pyrexia . . .	Pyrexia . . .	Pyrexia . . .	—	Well.
Appearance of patient . . .	Ill . . .	Ill . . .	Seriously ill . . .	Well . . .	
Diplopia . . .	Present if eye is in a position of deviation.	Present if eye is in a position of deviation.	Vision impaired early (extreme orbital œdema).	On attempting to turn eyes.	Present if eye is in a position of deviation.
Pain . . .	Severe . . .	Severe . . .	Throbbing . . .	Pain on trying to turn eyes.	Usually absent except from pressure of bony growths on sensory nerves.
Tenderness . . .	Localised to site of bone lesion if at the orbital margin.	No localised tenderness.	No localised tenderness.	None, except on backward pressure of the eyeball.	Absent.
Eyelids . . .	Red and swollen . . .	Red and swollen . . .	Extreme dusky redness and swelling.	Moderate or slight swelling.	No swelling apart from extension of growth. (N.B.—Neurofibromatosis usually involves upper eyelid.)
Conjunctival chemosis . . .	Marked . . .	Marked . . .	Marked . . .	Well marked . . .	Usually absent.
Proptosis . . .	Present in deep or posterior orbital periostitis; slight in periostitis of the orbital margin.	Present . . .	Extreme . . .	Slight . . .	Present.
Proptosis direction . . .	Varies with site of origin of periostitis.	Mainly directly forwards.	Mainly directly forwards.	Mainly directly forwards.	Directly forwards in tumours of the optic nerve. Lateral displacement according to site of origin of other tumours.



Unilateral or bilateral	Unilateral . .	Unilateral . .	Often bilateral in later stage.	Unilateral . .	Unilateral . .	origin of other tumours.
Movement of eyeball	Varying with degree of proptosis.	Varying with degree of proptosis.	Varying with degree of proptosis.	Marked limitation in comparison with slight degree of proptosis.	Usually fair; limitation late.	Unilateral.
Palpable swelling.	In periostitis of orbit margin, or pointing abscess.	—	—	—	In various tumours.	In arterio-venous aneurysm, in aneurysm of the carotid or of the ophthalmic artery, and in some vascular tumours.
Pulsating exophthalmos and bruit.	—	—	—	—	—	—
Mastoid cedema	—	—	Sometimes present (thrombosed petrosal sinus). Develop quickly.	—	—	—
Cerebral symptoms.	—	If meningitis supervenes.	Found impaired if able to be tested.	—	Gradual loss in some cases.	Generally normal.
Vision . . .	Impaired if nerve also inflamed.	Optic neuritis if anterior end of nerve involved.	Distension of retinal veins; sometimes papilloedema.	—	—	—
Fundus . . .	Normal	—	—	—	—	—
X-ray . . .	—	—	—	—	Shadow with bone tumour.	Good except in large osteoma, or carcinoma or sarcoma.
Prognosis . . .	Fair in anterior periostitis, grave in posterior.	Risk of Grey's meningitis.	Fatal . . .	Good . . .	—	—



(3) *Local treatment* in the form of moist heat by fomentations and hot bathing relieves pain and hastens the pointing of an abscess. Incision, and drainage by means of a small rubber tube or strip of rubber, should be adopted early. When necrosis of bone occurs, a discharging sinus persists until the necrosed bone separates and is discharged, or is removed surgically. A deep, adherent scar is produced, with resulting ectropion in many cases. A plastic operation may be required to correct this deformity.

**Inflammation of the Accessory Nasal Sinuses.**—The accessory nasal sinuses, comprising the frontal, sphenoidal and maxillary sinus, and the ethmoidal cells, are subject to inflammation in their lining mucous membrane. Such inflammations are acute or chronic. The acute forms are liable to extension into the orbit, especially in the case of the ethmoid cells, with the production of orbital periostitis or cellulitis. The more chronic types of inflammation of a sinus may result in the formation of a mucocele which gradually distends the cavity, and may extend into the orbit. Thus a mucocele of the frontal sinus may cause bulging downwards into the upper and inner part of the front of the orbit. A mucocele of the ethmoid projects especially into the nasal wall of the orbit, and displaces the eyeball forwards and outwards. Acute or chronic disease of a nasal sinus may cause serious impairment of vision by the development of inflammation of the optic nerve as retrobulbar neuritis (see p. 204), or of the uvea as iritis, cyclitis or choroiditis. These conditions require immediate treatment by a rhinologist.

**Neoplasms.**—New growths of the orbit apart from those which start in the eyelids, are not common. New growths may start in the contents of the orbit or in the orbital wall, or encroach upon it from surrounding structures, such as the nasal sinuses, or the eyelids.

(a) **CONTENTS OF THE ORBIT.**—The *optic nerve* is the subject of new growths, which, by their position within the conical space bounded by the rectus muscles, cause central proptosis (see p. 207). A *cavernous angioma* occurs in connection with the blood vessels of the orbit, and often also involves an eyelid. A *dermoid cyst* is occasionally found in the anterior part of the orbit, in the upper nasal or upper temporal region. The *lacrymal gland* is rarely the site of a *mixed tumour* or a *carcinoma*. A *sarcoma* may arise in the connective tissue of the orbit, or in the dural sheath of the optic nerve.



(b) ORBITAL WALL.—An *osteoma* of the orbit is usually of dense compact bone like ivory, and is then known as an ivory osteoma. This type generally implicates the roof of the orbit and extends into the cranial cavity. Such a growth can only be removed in part, and even then at considerable risk of opening the cranial cavity. Occasionally a more or less pedunculated osteoma of cancellous bone is found, and is more readily removed.

(c) The mucous membrane of the ACCESSORY SINUSES is sometimes the source of a *carcinoma* which extends into the orbit.

TREATMENT.—The extent of a neoplasm must be carefully estimated, and X-ray evidence must be considered in the case of an osteoma. Palpation with the finger between the eyeball and the orbital margin, if necessary under an anæsthetic, often assists in the definition of the extent of a growth. An exploratory operation through the ocular conjunctiva on the outer side, with division of the external rectus, gives greater access to the orbit. In the case of very large growths and of malignant tumours limited to the orbit, exenteration of the whole of the contents of the orbit is required, with the sacrifice of the eyeball.



## CHAPTER XV

### OPERATIONS

#### GENERAL CONSIDERATIONS

(A) PRELIMINARY MEASURES.—Only a small proportion of ophthalmic operations are in the nature of emergency procedures. It is therefore possible to take certain preliminary measures, which are of special importance when the operation involves opening the eyeball. These measures are as follows :—

(1) Careful general examination of the patient for the presence of any focus of infection in the teeth, tonsils, nose, accessory sinuses, scalp and gastro-intestinal tract, and adequate treatment of any lesion found.

(2) The taking of a smear and culture (incubated for forty-eight hours) from the conjunctival sac. It is usual to consider *B. xerosis* and *staphylococcus albus*, if present in small numbers, as non-pathogenic. If other organisms are present an intra-ocular operation should be deferred until suitable local treatment has destroyed them.

(3) Examination for patency of the lacrymal passages by pressure over the sac to determine whether there is regurgitation of mucus or pus, and in cases where there is any doubt by syringing through the canaliculi. In some cases it may be necessary to remove the sac before, say, extraction of cataract. In cases of emergency, *e.g.*, acute glaucoma, we may seal the lacrymal puncta by searing them with the galvano-cautery.

(4) Examination of the urine, especially for sugar.

(5) Estimation of the blood pressure. If this be excessive, venesection with free catharsis before operation and performance of the latter in a semi-recumbent posture, may avert the occurrence of a disastrous intraocular hæmorrhage.

(6) The administration of a suitable laxative twelve hours before operation.

(B) ANÆSTHESIA.—Adequate anæsthesia for intraocular operations in adults, when there is no vascular congestion, can be obtained by the instillation of drops of sterile 5 per cent. cocaine



at three-minute intervals through a period of a quarter of an hour. The lids should be kept closed in the intervals between instillations, as cocaine has a deleterious effect on the corneal epithelium. It is usual to add some adrenalin 1 : 2,000 to the last instillation of cocaine. In the presence of vascular congestion—as in acute glaucoma—it is usually better to administer a general anæsthetic. Children, as a rule, require a general anæsthetic. Operations on the lids, lacrymal apparatus and extraocular muscles are, in adults, usually performed under infiltration anæsthesia, the solution injected being novocaine 2 parts, adrenalin 1 : 10,000, 98 parts. Excision of the eye is best done under a general anæsthetic. In cases where this is contra-indicated, the operation can be performed after deep infiltration of the orbit with novocaine and adrenalin.

(C) ANTISEPSIS.—Special care is taken during the time before operation with regard to washing the patient's face and hair. For external operations it usually suffices to paint the area involved with 1 per cent. alcoholic tincture of iodine. If the usual 2 per cent. solution is used there may be a troublesome dermatitis afterwards. The conjunctival sac should be well doused with warm 2 per cent. boracic lotion, the lids being everted. Special care should be taken about the inner canthus, which should be carefully cleared with swabs soaked in lotion.

### OPERATIONS ON THE LACRYMAL PASSAGES

(1) **The Three Snip Operation.**—After cocainisation, put a little solid cocaine on to the inferior punctum and along the conjunctiva between this point and the caruncle. After a couple of minutes wash the eye out with boric lotion and enlarge the punctum with a dilator. Now pass a Weber's knife along the caniculus, with the cutting edge directed towards the conjunctiva. On raising the handle an incision is made which divides the tissues lying between the posterior wall of the duct and the conjunctival sac. A pair of fine, sharp-pointed scissors is now taken and a triangular piece of this tissue is excised. By this means a relatively large communication is made between the lacus lacrymalis and the canaliculus. The object of removing this portion of tissue is to prevent the healing which so frequently occurs when only a simple incision is made.

(2) **Excision of the Sac.**—The conjunctiva is *anæsthetised* with a few drops of 1 per cent. cocaine solution, the punctum is dilated and the sac washed out with a little 1 per cent. cocaine. Injec-



tions of novocaine and adrenalin are then made along the line of the skin incision, and more deeply into the tissues, above and below the tarsal ligament. In the latter positions the needle should be pushed in until in contact with periosteum. In giving the injection above the tarsal ligament, the point of the needle should also be turned and then thrust downwards so as to allow of injection along the walls of the sac and naso-lacrymal duct.

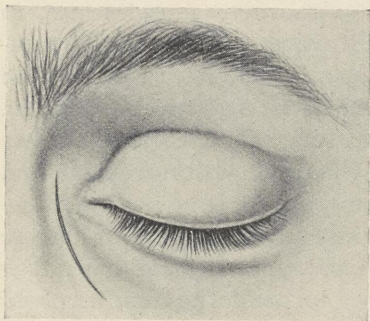


FIG. 146.—Removal of lacrimal sac.  
Line of incision.

The operation may be commenced within three minutes of giving the last injection. The incision begins at a point 3 mm. above and internal to the inner canthus. It should be 2 cm. in length, the first part of its extent being vertical and the lower part curving outwards (*vide* Fig. 146). The skin may be steadied by pressure backwards with the thumb against the bone. The lateral

margin of the skin is now dissected up from the underlying tissues and the tear duct speculum (Fig. 147) is introduced. This helps to check bleeding and renders taut the superficial fascia, which is picked up by a pair of forceps and slit throughout the length of the incision with a pair of small, slightly curved, sharp-pointed

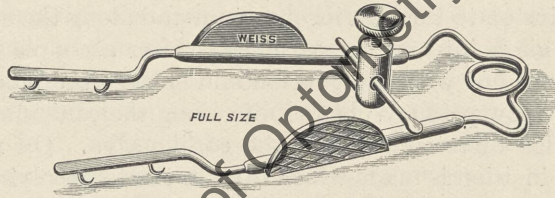


FIG. 147.—Tear sac speculum.

scissors. This exposes the orbicularis, which is dealt with in a similar manner.

It is now necessary to locate the anterior lacrymal crest by feeling with forceps along the inferior margin of the orbit on to the side of the nose. This landmark is of supreme importance in the operation, and the next step should not be taken until it has been definitely located. *Exposing the sac* : The deep fascia passes between the anterior and posterior crests of the lacrymal bone,



being thickened above to form the internal tarsal ligament. It is divided with the scissors along a line  $\frac{1}{2}$  mm. behind the anterior lacrymal crest, the internal canthal ligament being cut through at the upper end of the incision.

The sac is now exposed in the lacrymal fossa (Fig. 148) and has to be *peeled out* of its bed in the following manner. Pick up with forceps the lateral margin of the divided fascia and separate the sac from it with the points of the closed scissors, starting below and cutting through the canaliculi in the upper part of the wound.

Now free the median wall of the sac in a similar manner, but starting above. The sac can now be grasped with the forceps and pulled forwards a little. In this position it is possible, by careful dissection with the scissors, to free the upper end of the sac. Some hæmorrhage may occur at this point, but can be checked by pressure with swabs soaked in adrenalin. The sac is now free except at its lower end. The attachment here is divided as far down as possible by passing the scissors down the naso-lacrymal duct and cutting through the remaining attachments. The sac can then be removed. The wound is swabbed dry and a probe passed down the naso-lacrymal duct, which should then be

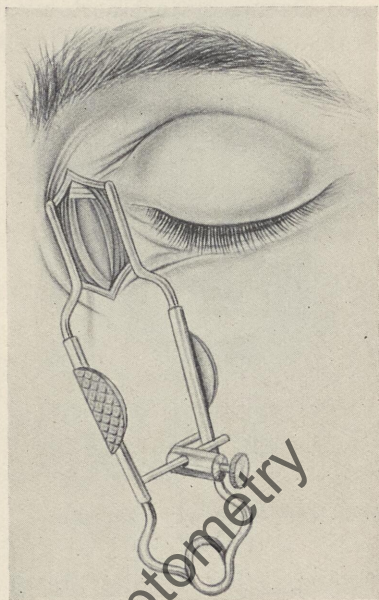


FIG. 148.—Sac exposed at bottom of wound. [Drawing by Hamblin.]

curetted with a small sharp spoon. Finally an electro-cautery at dull red heat is used to destroy any remnants of mucous membrane, for which the lacrimal fossa should be carefully examined.

A fairly deep cavity is now left which is well cleansed with boric acid lotion and swabbed out. The speculum is removed and the edges of the skin united with three interrupted sutures of black silk.

*Dressing.*—Before applying this make a careful inspection of the cornea for any scratches or abrasions which may have been



made during the operation. If these are found there is a possibility that hypopyon ulcer may develop, and the case should be treated on these lines (*vide* p. 134). If the cornea is intact a small roll of gauze is applied to the united margins of the wound and covered by a pad of gauze and wool, secured by a bandage. The first complete change of dressings is made on the third day and the stitches removed on the fifth.

*Excision of the palpebral portion of the lacrymal gland* is sometimes required in cases where troublesome epiphora persists in spite of removal of the tear sac.

(3) **Dacryo Cystorhinostomy** is a procedure advocated by West for dealing with lacrymal obstruction. The operation is per-

formed intranasally, and consists essentially in establishing a new opening between the tear sac and the nose. It has proved remarkably successful in the hands of some rhinologists.

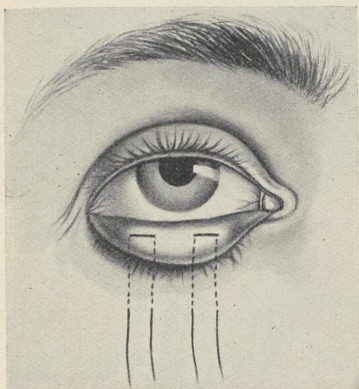


FIG. 149.—Sutures for spasmodic ectropion.

### ECTROPION

(1) **Spasmodic** is best dealt with by *Snellen's sutures*. Two doubly-armed stitches are used; the needles are passed as shown in Fig. 149, through the most prominent part of the conjunctiva, at the junction of the inner and middle thirds of the lid

affected. The needles are made to emerge through the skin about 2 cm. from the lid margin. The sutures are tied over small pads of iodoform gauze sufficiently tightly to bring the lid back into its normal position.

(2) **Senile**.—(A) In very mild cases it may suffice to make two linear applications of the *cautery* to the conjunctival lining of the lid, the subsequent cicatrization drawing the lid back into its correct position. Occasionally a similar result may be obtained by painting the conjunctiva with 2 per cent. *silver nitrate*.

(B) *Skin Parsal Operation* (*Kuhnt-Szymanowski*).—This is required in the more marked cases and is performed under novocaine anesthesia. It consists essentially in shortening the lower lid by removing a triangular-shaped piece of tissue. In order to



avoid the formation of a gap in the lid margin the removed portions of skin and tarsus do not overlie each other. The steps of the operation are as follows :—

(a) *Splitting the Lid.*—The lower lid is grasped between the thumb and finger and a bent keratome is introduced at a point slightly to the inner side of the middle of the lid and just behind the lashes. The blade of the keratome is held parallel with the lid and pushed in so as to separate the tarsal and cutaneous layers. The incision is repeated at a point nearer the outer canthus, and a third incision may be required before a complete separation is

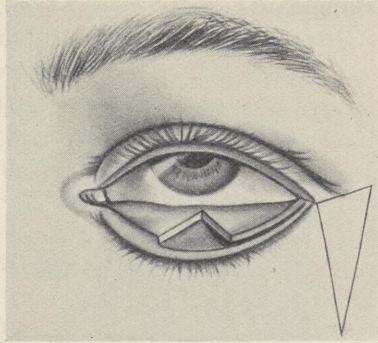


FIG. 150.—Skin tarsal operation for ectropion. Tarsal wedge removed, lid split, skin in triangle not yet removed.

effected of the tarsal and cutaneous layers of the outer half of the lid.

(b) *Removal of Tarsus.*—A triangular piece of tarsal cartilage and conjunctiva is now removed with short, straight scissors from the centre of the lid (Fig. 150). It is important to gauge the right amount to be removed. This is best done by pinching up a fold of the tarsal cartilage with a pair of forceps and seeing how large a portion must be grasped in order to make the lid lie flat on the globe.

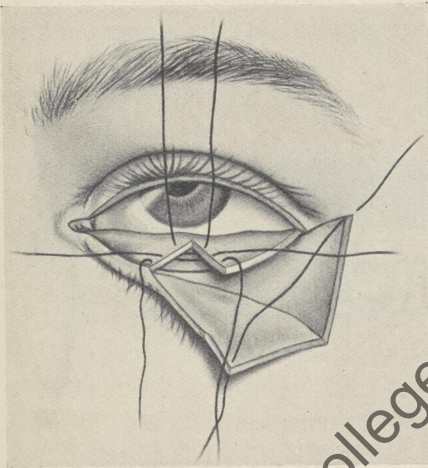


FIG. 151.—Skin tarsal operation. Stitches ready for tying. [Drawing by Hamblin.]

(c) *Removal of Skin.*—The triangle outlined in Fig. 150 is carefully dissected up and removed and the skin of the lid is well undermined. The lash-bearing area of the lower lid is removed for a distance corresponding with the base of the excised triangle of skin.

(d) *Insertion of sutures* is performed as shown in Fig. 151. An



additional suture, not shown, is usually applied over a bead to secure apposition of the skin to the tarsus, and two more to secure co-adaptation of the skin margins along the line of excision of the triangle.

Dressings are applied and both eyes should be kept covered for four days. At the end of this period the sutures are removed from the tarsus, the skin sutures being removed a day later.

In cases where ectropion occurs from cicatrisation following wounds and burns, skin grafting must be performed. A description of these procedures is outside the scope of this book.

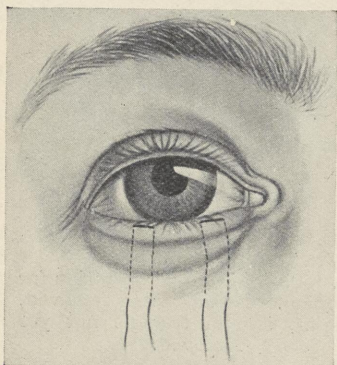


FIG. 152.—Sutures for entropion.

operation for cataract, *strips of adhesive plaster* may be used to draw out the inverted lid border. The strips should be 1 cm. wide and 2 cm. long. They are applied at the upper end to

#### ENTROPION AND TRICHIASIS

(1) **Spasmodic.** — (A) In mild cases, such as are occasionally produced by the bandaging after

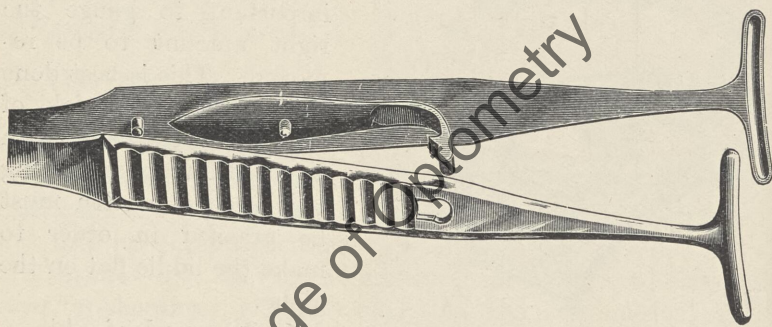


FIG. 153.—Entropion forceps.

the lid margin, the lower end being pulled downwards and fixed to the skin.

(B) In more severe cases *Gaillard's sutures* are used. These are passed as shown in Fig. 152, by means of long needles, curved on the flat, introduced through the highest point of the inverted lid and made to emerge at the lower border of the orbit. They



should lie one on each side of the middle third of the lid, and are tied over small gauze pads. They may be removed after the fourth or fifth day.

(2) **Senile** entropion of the lower lid is treated as follows, under novocaine infiltration anaesthesia. A fold of the skin of the affected lid is picked up with the special T-shaped forceps shown in Fig. 153, a sufficient amount being included to correct the defect. Scissors are then used to cut off the portion of skin included in the grasp of the forceps. A raw area is now left in which lies the orbicularis muscle. The portion exposed should be grasped with fixation forceps and cut away with scissors. The margins of the wound are then united with three or four interrupted silk sutures and a dressing applied. The stitches are removed on the fifth day.

(3) **Cicatricial.** — The commonest form of this is due to *old trachoma* and affects the upper lid. Mild cases, where there are just a few lashes irritating the cornea, can often be treated by removal of the misplaced cilia, a procedure which has to be repeated every month or so for a considerable period of time, or electrolysis may be used. Other cases, of a more severe character, are best dealt with by the following procedure :—

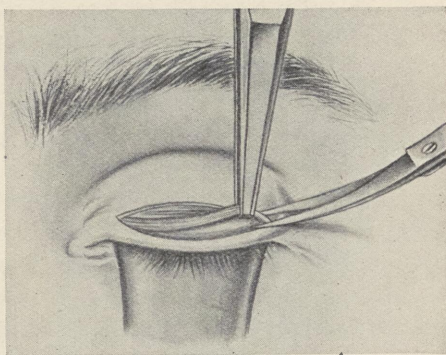


FIG. 154.—Sutures for entropion of upper lid. Skin incision made, orbicularis being removed.  
[Drawing by Hamblin.]

*Muscle Tarsal Operation (of Holz-Anagnostakis).*—A horn spatula is inserted under the upper lid, which has been infiltrated with novocaine and adrenalin. An incision is made through the skin along the whole length of the lid, parallel with its margin and 3 mm. above it. The margins of the wound are dissected up and the exposed fibres of the orbicularis are removed with scissors (Fig. 154), thus exposing the tarsal cartilage, which is usually much thickened and bent. A sharp scalpel is now entered, somewhat below the upper margin of the tarsus and parallel to its plane, and with a sawing movement downwards thin slices are cut away, avoiding perforation. The uppermost part of the cartilage



and the lid margin are not included in the area thinned. Three sutures are now passed, two of which are shown in Fig. 155. The needle first enters the skin through the upper wound border. The latter is now retracted by an assistant and the needle passed through the upper tarsal border, in a horizontal direction, so as to avoid perforation, and is then carried on through the skin of the lower border of the wound. The central stitch is inserted first and then the lateral and mesial ones.

The effect of tying these sutures is to drag the lower wound border up to the level of the top of the tarsal cartilage and thereby bend the lid so as to make it concave forwards, thus over-correcting the deformity. This over-correction disappears in the course

of a few days and the end result is excellent. The eye should be covered with a dressing and the stitches can be removed on the fourth day.

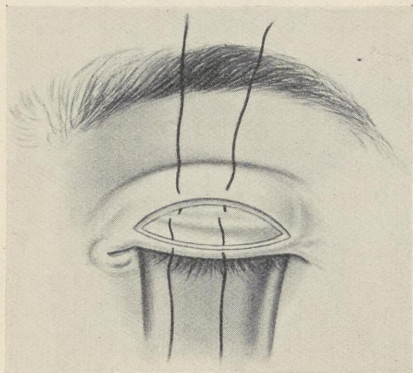


FIG. 155.—Operation for entropion of upper lid. Inner and middle sutures inserted. [Drawing by Hamblin.]

#### CATHOTOMY

This is an operation for widening the palpebral fissure. It may be required in cases of acute conjunctivitis, where there is profuse discharge and œdema of the lids, in cases of blepharospasm, and in some cases

of spasmodic entropion. It is also done in ankyloblepharon, blepharophimosis, in operations on puphthalmic eyes, in some cases of cataract, and, finally, it represents the first stage in exenteration of the orbit.

The operation is performed under infiltration anæsthesia, some cocaine being dropped also into the conjunctival sac. The skin of the outer canthus is stretched by the thumb and forefinger, and the blunt end of a straight pair of scissors is thrust into the conjunctival sac beneath it. The skin and conjunctiva are then cut through with one stroke of the scissors.

If the effect is to be *permanent*, two additional cuts should be made with a small pair of scissors to sever the connective tissue strands attaching both lids to the orbital margin. The conjunctiva is now slightly undermined and can be attached with sutures



to the raw edges of the skin wound, thus preventing their adhesion.

### TARSORRAPHY

The object of this operation is to shorten the palpebral fissure.

INDICATIONS.—It is most commonly performed for neuro-paralytic keratitis, due to the corneal anæsthesia which may follow lesions of the ophthalmic division of the fifth nerve (*e.g.*, herpes, alcohol injection of the Gasserian ganglion, etc.). It may also be required when exophthalmos is present, as in Graves' disease, or in tumours of the orbit and in conditions of lagophthalmos.

TECHNIQUE.—If the lids are not already anæsthetic they should be rendered so by infiltration with novocaine and adrenalin. The lower lid is now everted, and its sharp posterior margin is removed over the middle two-thirds of the length of the lid, by means of a sharp pair of scissors, curved on the flat. The same procedure is then repeated with the upper lid. The raw areas are united by three sutures. It is best to pass these from the conjunctival surface of both the upper and lower lids, so that double-armed sutures are required. The eye is covered with a dressing and the stitches removed at the end of the week, by which time a firm union will have occurred. In some cases it may not be necessary to unite so large an area of the lids, and in these the adhesions can be planned accordingly. In the neuroparalytic cases it is well to leave the adhesion undisturbed for a period of two or three months and then gradually cut it through 1 or 2 mm. every month until an adhesion about 1 mm. broad is left opposite the temporal margin of the cornea. This may be severed later, but a frequent result of so doing is to cause a recurrence of the keratitis.

### PTOSIS

INDICATIONS.—Most of the cases requiring operation are congenital, since in acquired ptosis the other muscles supplied by the third nerve are also paralysed, so that the eye is divergent and would cause diplopia if uncovered. Two operations may be described.

(1) **Hess' operation** is of value in cases where there is no paralysis of the frontalis muscle. It is performed under infiltration anæsthesia as follows :—

The brow is shaved and a horizontal incision made through it, dividing only the skin. The latter is now undermined by careful



dissection with a knife to a point near the edge of the lid, the skin being held forward with forceps.

Three strong silk sutures are doubly armed with long curved needles. The first pair are passed through the skin of the upper lid 4 to 8 mm. from its lower margin (Fig. 156) and brought out through the incision in the brow. The outer and inner sutures are inserted in the same way, each being about 1 cm. from the middle stitch. The needles of the latter are now pushed on, under the upper margin of the wound, deep to the frontalis, and made to

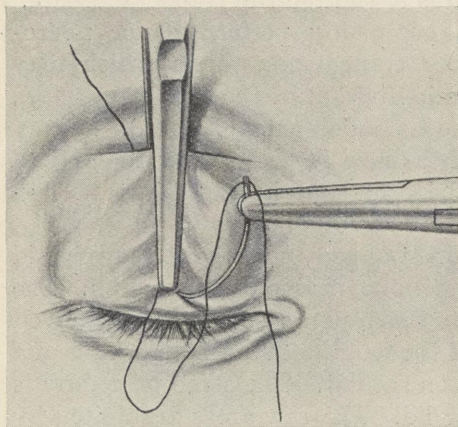


FIG. 156.—Hess' operation for ptosis.

emerge close to one another,  $1\frac{1}{2}$  to 2 cm. above the incision. The outer threads are treated in the same way, but the inner ones should be inclined slightly inwards. When they are tightened the lid is drawn up. They should be tied over gauze pads so as to give a slight over-correction. The skin wound is united with several interrupted sutures.

*After-treatment.*—The eye should be covered with a celluloid shield, held in position with strapping and containing a small pad of moist gauze. By this means the cornea is kept free from the ulceration which would otherwise ensue as a result of its not being completely covered by the upper lid. The shield is removed when secretion is present and the eye requires cleansing. The skin stitches may be taken out on the fourth day, but those elevating the lid should be left at least fourteen

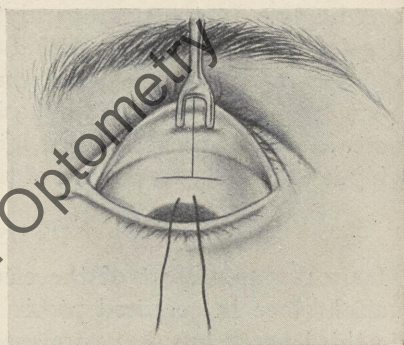


FIG. 157.—Motais' operation for ptosis, showing conjunctival incision. Upper lid retracted with double hook.



days, or even longer, in order to cause the formation of fibrous tissue cords along them.

(2) **Motais' operation** consists in using part of the superior rectus muscle to elevate the lid. It is performed under infiltration anaesthesia, some cocaine being also dropped into the conjunctival sac.

A suture is first passed through the conjunctiva at the upper limbus, so that the eye can be well drawn down. The lid is then everted and the convex upper tarsal border drawn upwards by a hook (Fig. 157). A horizontal incision 8 mm. long is made through the conjunctiva, its centre being 6 mm. above the limbus. Another incision is made backwards from this point, through the fornix, up to the convex border of the tarsus (Fig. 157). The tendon of the superior rectus can now be exposed and a squint hook passed beneath it from within outwards (Fig. 158). The middle fibres of the muscle and tendon are grasped with forceps and isolated from the neighbouring fibres with a pair of closed scissors. A fine, strong, silk suture, armed with two small curved needles, is then passed round this centre portion just above its insertion into the sclera and firmly tied. The insertion is cut through and a narrow tongue of muscle is isolated, held in its free end by the ligature.

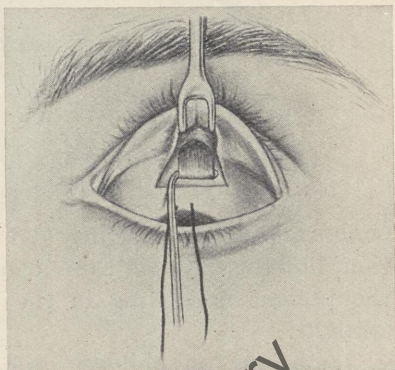


FIG. 158.—Motais' operation. Exposure of superior rectus.

A small incision is now made through the skin of the lid, about 2 mm. from the lid margin, and by means of a fine pair of sinus forceps a track is made between the skin and the anterior surface of the tarsus. The track is made to communicate with the conjunctival incision shown in Fig. 158. Two needles can then pass along this track, blunt ends foremost, until their eyes emerge through the conjunctival wound. The ends of the superior rectus ligature are passed through the eyes of the needles, which are then drawn back again through the skin wound. Traction on the threads will now bring the little tongue of muscle over the anterior surface of the tarsus up to the wound in the skin. This wound is



closed by passing the needles through its upper and lower margins and tying the suture. The conjunctival wound is closed with several catgut sutures and both eyes are bandaged, the dressing being changed daily, or, alternatively, the celluloid shield employed in Hess' operation is supplied. The sutures are removed at the end of eight days.

### OPERATIONS FOR SQUINT

The question of operation in concomitant cases has been discussed on p. 234. In cases of long-standing paralysis of an extra-

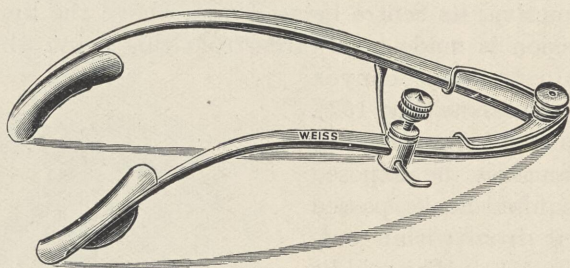


FIG. 159.—Eye speculum with solid blades for keeping the lashes back.

ocular muscle, an unsightly deviation may be overcome by operation, but the diplopia cannot, of course, be abolished except when the patient is looking in the direction in which the eyes are straight.

Operations on children are, in our experience, more satis-



FIG. 160.—Fixation forceps with toothed ends for holding conjunctiva.

factorily carried out under general anæsthesia. Under cocaine there is always a certain amount of pain caused by the necessary manipulations of the muscles. If this is abolished by deep infiltration with novocaine, the muscles are paralysed, and it is just as difficult as it is under general anæsthesia to tell whether the eyes are straight at the end of the operation. In general, it is found that tenotomy of the internal rectus will yield from 15 to 20 degrees of correction. If the deviation exceeds this amount, advancement or tenectomy of the external rectus should be performed in addition. This may be done at the same operation, or its performance may be delayed for three months, in order to see how much deviation still remains for correction.



(1) **Tenotomy of the Internal Rectus.**—The eye is held open with a speculum (Fig. 159); a pair of fixation forceps (Fig. 160) is used to raise a horizontal fold of conjunctiva starting about 3 mm. from the limbus, and a vertical incision is made through this with a pair of scissors. The incision should be 5 to 7 mm. long,

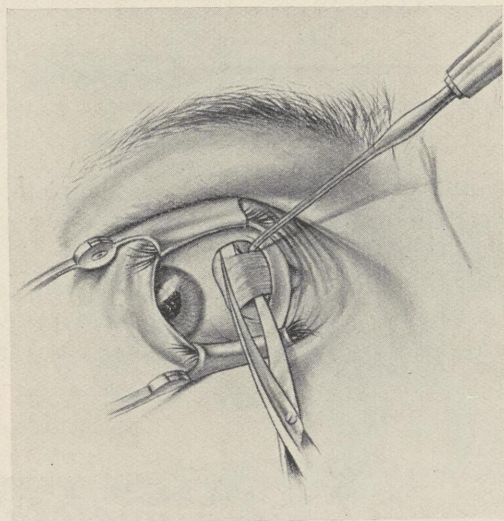


FIG. 161.—Tenotomy of internal rectus.

and distant about 4 mm. from the limbus. The nasal margin of the wound is dissected up for a short distance, and the scissors are then made to cut into the episcleral tissue above the line of the upper margin of the muscle (Fig. 161 shows the position of this) at about 6 mm. from the limbus. A large squint hook (Fig. 162)



FIG. 162.—Large strabismus hook.

is now taken and passed through the hole in the episcleral tissue, until its blunt end can be seen, covered by the episcleral tissue lying below the tendon. This tissue is snipped through with scissors and the muscle lies on the squint hook. It is then a simple matter to cut the muscle away from its insertion with a pair of scissors (Fig. 161). A small squint hook



(Fig. 163) is now passed into the wound, and moved up and down to determine whether all the tendon fibres have been severed. If any are found, they must, of course, be cut through. Care must be taken, however, not to divide widely beyond the lateral borders of the tendon, or the lateral expansions will be severed, with resulting divergence later. The conjunctival wound is then closed with



FIG. 163.—Small strabismus hook.

one or two sutures and the operation is complete. It usually suffices to cover the one eye for four or five days, at the end of which time the stitches are removed.

The advantages of tenotomy lie in its simplicity and the ease with which it can be performed. Even in experienced hands, however, the result is variable, and, in some cases, the eye may

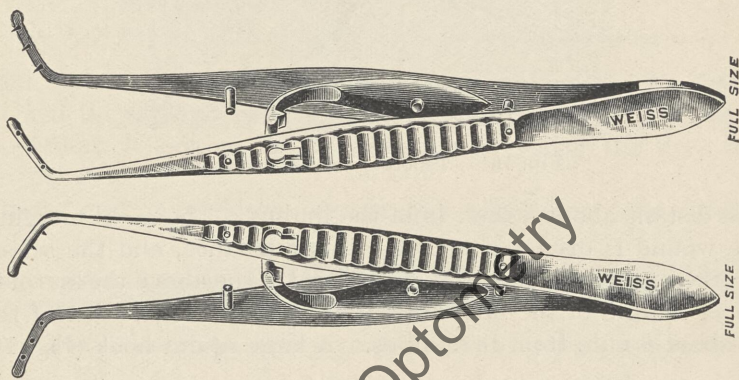


FIG. 164.—Princes' forceps for holding the recti muscles. They have a catch for keeping them closed. One pair is for the right eye, the other for the left.

become widely divergent in the course of ten or fifteen years. This fact has led some authorities to abandon the operation altogether and rely solely on advancement of the external rectus, performing the operation on both eyes if necessary.

The uncertainty of the result can, however, be largely overcome by stitching the muscle down to the sclera after its insertion has been severed, the operation being then known as—

(2) **Recession.**—It is performed as follows: The conjunctival incision is made just external to the semilunar fold and the con-



junctiva lying between this line and the cornea is gently undermined with scissors. The muscle is isolated as before with the hook, but this is then withdrawn and a pair of Prince's forceps (Fig. 164) slipped on in its place. The tendon of the muscle is then cut with scissors as close to the globe as possible, the stump of the insertion being grasped with forceps, and the eye turned strongly outwards. The point to which the tendon is to be anchored on the sclera must now be chosen. It is found that, in general, each millimetre of recession produces 5 degrees of correction. If the deviation to be corrected is 20 degrees, one should therefore select a point on the sclera 4 mm. from the insertion of the tendon. A silk stitch is now passed through the centre of the temporal edge of the conjunctival wound (Fig. 165). It is then made to pick up a few fibres of the sclera at the predetermined point, and carried on through the fringe of muscle beyond the grasp of the Prince's forceps, and then through the conjunctiva of the nasal margin of the wound. Care must be taken not to penetrate the sclera while inserting the stitch, as it is usually rather thin; also the stitch should be passed vertically in this part of its course. Similar stitches are inserted above and below, the forceps are removed, and the stitches carefully tightened and tied. It is advisable after this operation to cover both eyes for ten days, and not to remove the stitches until the lapse of this period. The result obtained by this operation is satisfactory, and can be graded to meet the requirements of individual cases. There is, however, a slight risk of perforating the sclera; also it takes a considerably longer time to perform.

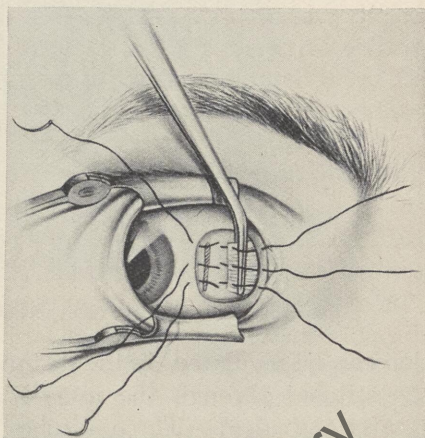


FIG. 165.—Recession of right internal rectus to show sutures.

(3) **Tenectomy** (Fig. 166) is performed in very much the same way as recession, except that the external rectus is the muscle usually dealt with. The stitches, however, are passed differently, the technique being as follows: A double-armed suture is taken



and one needle is passed from the deep surface through the stump of the tendon and the conjunctiva. The other needle is passed from the under surface, through the muscle behind the forceps, and then out through the conjunctiva. The effect of the opera-

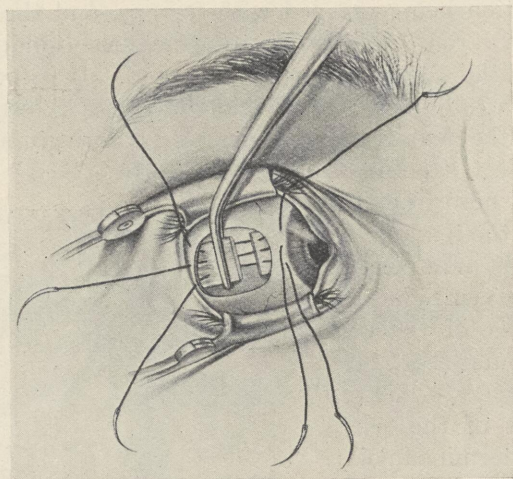


FIG. 166.—Tenectomy, right external rectus to show sutures.

tion can be regulated by the distance separating the forceps from the stitches through the muscle, the greater the distance the greater the effect. Three stitches are inserted, as shown in the figure; the muscle is then cut between the forceps and the stitches,

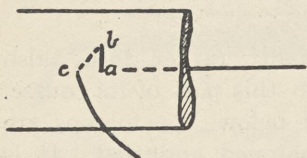


FIG. 167.—Whip stitch. Needle passed through muscle from its inner surface at *a*, back again through *b*, and finally out at *c*. Dotted lines indicate portions of suture deep to the muscle.

the latter being tightened and tied. The effect can also be regulated, in some degree, by the tightness with which the sutures are tied. It is therefore advisable to tie these first in a double twist (surgical knot) so that they can be drawn a little tighter or loosened before completing the knots.

The after-treatment for this operation, and for advancement, is the same as for recession.

(4) **In advancement** the front ends of the stitches are carried through the sclera and conjunctiva in advance of the insertion of the tendon. Since the external rectus in this operation is put under more tension than in tenectomy, it is usually advisable to make the central suture through the muscle a "whip stitch."



This is done as follows (Fig. 167) : The needle comes through the muscle at *a*, and is reintroduced at *b*, about  $1\frac{1}{2}$  mm. above *a*, and passed through the muscle, to be brought out again at *c*. The effect of this is to include the bundle of fibres between *a* and *b* within the grasp of the suture, so that there is less liability for it to cut out.

Advancement produces a greater effect than tenectomy, but is a little more difficult to perform, and gives rise to greater post-operative reaction.

### ENUCLEATION

*The indications* for this operation have already been considered in the appropriate sections. Whenever possible, it is performed under general anæsthesia, but with a special technique of deep infiltration of the orbit, it can be done under local anæsthesia. *The steps of the operation* are as follows :—

After insertion of the speculum, a fold of conjunctiva is picked up in the horizontal meridian as near the limbus as possible, and snipped through with a pair of scissors. The blunt-ended blade of a small slightly curved pair of scissors is then passed through the hole, and the conjunctiva severed from its attachment to the limbus all the way round. The procedure is easier to perform if every now and again the closed scissors are introduced through the conjunctival wound and the blades forcibly opened, so as to separate the conjunctiva from the underlying sclera. The surgeon separates the lower periphery first, and then the upper. A large squint hook (Fig. 162) is now taken and passed under the internal rectus, which is then severed between the hook and the globe. The superior and inferior recti are treated in the same way, but the external rectus is divided outside the hook, so that a stump remains attached to the globe. The squint hook is now passed all round the eye, under the conjunctiva, to make sure that there are no undivided muscle attachments. Pressure backwards on the speculum will now dislocate the eye forwards, unless there are posterior adhesions, as in old panophthalmitis. The stump of the external rectus is grasped in forceps, the eye well adducted, and a closed pair of excision scissors, strongly made and curved on the flat, is passed backwards from the outside of the globe towards its posterior pole. When the closed blades encounter the optic nerve—which feels like a tightly-stretched cord—they should be opened slightly to include it within their grasp. In some cases of intraocular neoplasm it is necessary to



divide the nerve as far back in the orbit as possible. To effect this the scissors, when they have the nerve within their grasp, should be pushed backwards towards the apex of the orbit before their blades are approximated and the nerve is cut. The eye is now practically free, and can be removed, after a few strokes with the scissors have divided the remnants of the insertions of the oblique muscles. The cavity left should be tamponed with gauze and then irrigated with hot (160° F.) boracic lotion to arrest hæmorrhage. When this has been checked, the edges of the conjunctival wound are approximated by pinching them together with fixation forceps—no sutures being required. The cavity is then lightly packed with vaselined gauze plugging, and a pad and bandage applied. The dressing is changed and the socket cleansed with lotion, the day after the operation, the cavity being again lightly packed with the vaselined plugging, which may be omitted on the second day. After this a light pad should be worn for a few days, the socket being irrigated three times daily. A glass eye may be worn within a month or six weeks.

MODIFICATIONS OF SIMPLE ENUCLEATION.—Many operations have been devised to produce a mobile stump on which the glass eye shall rest. The effect of such an operation is that the glass eye moves in association with the fellow eye, so that in successful cases, it may be almost impossible for an observer to tell which is the artificial eye. Of these procedures, the following two deserve mention :—

(1) **Mule's Operation.**—This gives an excellent result, and can be used in recently injured eyes, in eyes blind and painful from glaucoma (provided there is no suspicion of a neoplasm), and in cases where only the cornea is diseased. Since the sclera is retained, the operation is obviously useless for cases of sarcoma of the choroid, or for cases of actual or potential sympathetic ophthalmia. It is performed as follows—under general anæsthesia.

An incision is made through the conjunctiva round the limbus, as in the first stage of enucleation. A Bier's knife or a scalpel is then passed through the sclero-corneal junction above, and the incision continued round the cornea with scissors. In the horizontal meridian it should extend into the sclerotic for a couple of millimetres, so that the incision is somewhat winged. The cornea with its two "wings" of sclera can now be removed and the contents of the eye eviscerated. The latter is best done with a



Mule's scoop (Fig. 168), the instrument being passed backwards so as to separate the iris, ciliary body, and, finally, the choroid from their attachments to the sclera. In this way the entire contents of the eye may be scooped out. A certain amount of

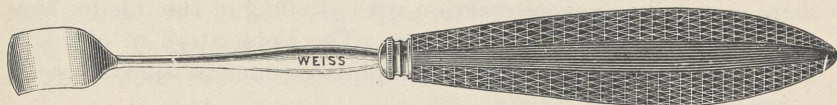


FIG. 168.—Mule's evisceration scoop.

hæmorrhage occurs when the central retinal vessels are divided at the optic nerve, but this is easily controlled by swabbing, and by irrigation with hot (160° F.) boracic lotion. It is important that no fragments of uveal tissue be left. The sclera should therefore be thoroughly swabbed out, and all hæmorrhage be arrested.

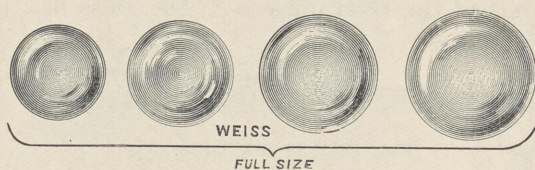


FIG. 169.—Mule's glass balls.

The next stage of the operation must not be undertaken until the entire inner surface of the sclera can be seen to be clear of clot and uveal tissue.

The edges of the scleral opening are now held apart with forceps, and a hollow glass ball (Fig. 169) is introduced by a special



FIG. 170.—Mule's introducer.

instrument (Fig. 170). The points of this instrument are passed into the scleral cavity, and pressure on the top of the handle will then push the ball in. It is important to choose a ball that will fit easily, so that the sclera will come over it without there being any tension on the stitches. The sclera may now be sewn up in the horizontal meridian, using interrupted sutures of strong white



silk. Catgut is not so satisfactory, as it may absorb before union of the sclera is complete. The conjunctiva is united in the vertical meridian with interrupted sutures of black silk, which can be removed at the end of a week.

*After-treatment.*—The eye is bandaged as in enucleation, but there is usually a severe reaction with swelling of the lids for the first few days after the operation. The application of a small ice-bag will help to diminish this, and, later, fomentations may be required.

(2) **Frost Lang Operation.**—This consists in inserting a glass ball into the cavity left in Tenon's capsule after removal of the whole eye. The operation has therefore a wider application than Mule's procedure, since it does not entail leaving the sclera. After the eye has been removed, the edges of Tenon's capsule are carefully picked up with four pairs of fixation forceps, and a purse-string suture of fine catgut is passed through the capsule, catching up the cut ends of the recti muscles. The glass ball is inserted



FIG. 171.—Graefe knife.

and the sutures tightened and tied. The conjunctiva is sewn up separately in a horizontal direction with interrupted black silk sutures. The cosmetic result of this operation is better than that obtained by simple enucleation, but the movement of the artificial eye is not so good as when Mule's operation has been done.

### CATARACT EXTRACTION

This operation is performed under local anaesthesia, the surgeon standing at the head of the table and his assistant on the side of the eye to be operated on. The operation is called "simple" when it consists solely in extraction of the opaque lens, and "combined" when it is combined with iridectomy, which may be complete or peripheral. In both cases the capsule of the lens is left in the eye.

**Simple extraction** is performed as follows: The pupil is dilated with homatropine and cocaine instilled twice at five-minute intervals, one hour before operation. This, of course, is omitted if the intraocular tension is above normal, or if there is any suspicion of glaucoma.

The incision is made with a Graefe knife (Fig. 171) held in the



right hand for the right eye, and the left hand for the left eye. The edge looks upwards, and the blade is parallel with the iris. The handle is held horizontally between the thumb and first and second fingers, the surgeon's hand being steadied by resting the little finger on the patient's head. The point of the knife enters the limbus 1 mm. above the outer end of the horizontal meridian (Fig. 172, A), and is pushed horizontally across the anterior chamber until the point is over the pupil. The knife handle is now slightly raised so that the point engages the capsule of the lens. It is pushed on for 2 or 3 mm. so as to lacerate the capsule, and the

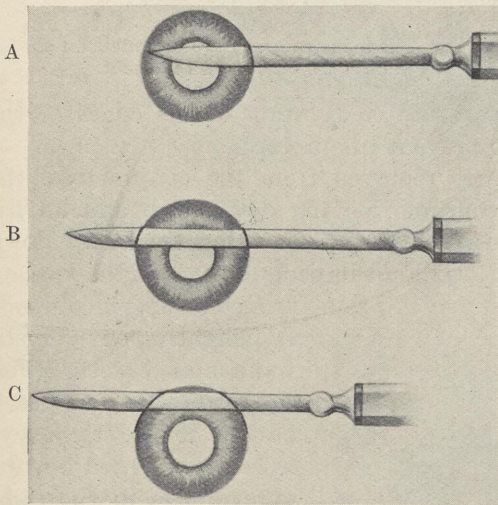


FIG. 172.—A, Cataract section, commencing the counter puncture. B, Counter puncture made. C, Commencing the section through the limbus. [Drawing by Hamblin.]

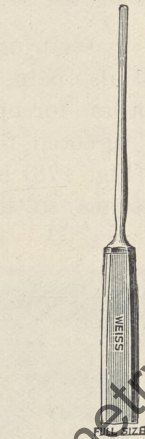


FIG. 173.—Iris reposer. For use, the end of the instrument should be slightly bent forward.

handle is then slightly lowered again. The knife is passed on across the eye, so that its point enters the cornea 1 mm. from the limbus in a position exactly opposite the first puncture (Fig. 172, A). If this is done, the point of the knife will emerge from the eye at the limbus (Fig. 172, B). If, on the other hand, the point of the knife is made to pierce the cornea in the apparent position of the limbus, it will emerge through the sclera. As soon as the counter-puncture is made, the knife, as it is pushed across the anterior chamber, is steadily carried upwards, without pause, at all sides parallel with the limbus, so that a large part of the incision can be made by this one movement (Fig. 172, C). It is now drawn back,



and with one or two sawing movements the incision is completed. After the section through the limbus has been made, the edge of the knife should be turned slightly backwards, so as to cut through the subconjunctival tissue for a short distance before cutting out through the conjunctiva itself. In this way one forms a conjunctival flap, attached to the cornea. Such a flap is of great

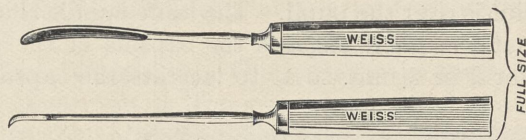


FIG. 174.—Curette; cystitome. These instruments are mounted on one handle, the cystitome at one end, the curette at the other.

assistance in securing accurate co-aptation of the edges of the wound; it also helps to prevent iris prolapse.

The fixation forceps are removed from the conjunctiva, the patient is directed to continue looking downward, and an iris repositor (Fig. 173) is used to turn the conjunctival flap down over the cornea, so that it will not impede the exit of the lens.

#### *Expression of Lens.—*

A slightly-bent cystitome and curette (Fig. 174) is now taken in each hand. If the right eye is being operated on, the curette held in the right hand is applied to the cornea about 1 mm. above its lower margin, the curette in the left hand being applied to the sclera just above the wound. For the left eye

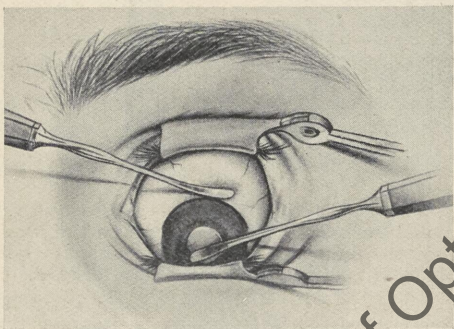


FIG. 175.—First stage of expression of lens—left eye.

[Drawing by Hamblin.]

the positions are reversed. Gentle pressure backwards is now made with both instruments (Fig. 175). That held in the right hand causes dislocation of the lens, while that held in the left hand causes the wound to gape and helps to guide the iris backwards over the lens. As a result of these manœuvres, the edge of the lens will shortly present in the wound. As soon as this happens, the instrument in the left hand should be reversed, and the point of the cystitome passed, with the blade facing the



surgeon, into the lens. The lens can then be gently lifted out of the eye, its lower edge being followed up with the curette held in the right hand (Fig. 176). The cornea is gently massaged in an upward direction with the curette to expel remains of the lens,

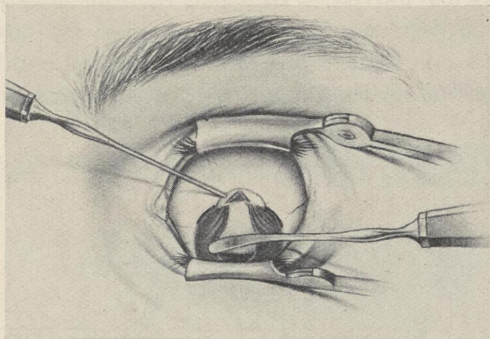


FIG. 176.—Lens emerging from eye, being lifted out with cystitome lower edge, being followed up with curette. Note small prolapse of iris above.

and the continuation of this movement will frequently result in the iris going back into the anterior chamber. If the cataract is a soft one, or is hypermature, it may be necessary to wash out the anterior chamber to remove remnants of lens matter. This is done by introducing into the wound a small metal cannula, attached by rubber tubing to an undine containing sterilised normal saline at body temperature (Fig. 177). The undine is then raised about 6 inches above the patient's head, so that the saline passes into the anterior chamber and washes out lens remnants.

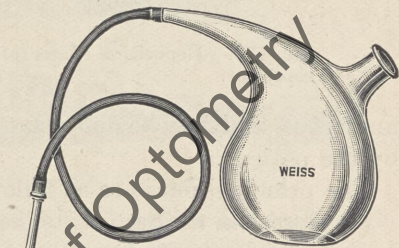


FIG. 177.—Irrigator for washing out the anterior chamber.

*Toilette of the Wound.*—As mentioned above, the iris may go back into position after massage of the cornea. If the pupil does not become round and regular, however, an iris reposer (Fig. 173) must be used. The point of this is introduced into the eye, and, by gentle stroking movements, combined with twisting of the instrument round its long axis, the iris can be made to go back into position. Fig. 178 shows this being done in a case where iridectomy has been performed, and gives an idea of the move-



ments necessary. The conjunctival flap is stroked back with an iris repositor, off the cornea on to the sclera. The repositor is then placed under the upper lid so as to hold it gently open while the speculum is removed. The patient is now directed to close his eyes, the upper lid being allowed to come down. The iris repositor is then removed, a thin pad of wool moistened in boric lotion is placed over the eye, and both eyes are covered with a double pad of wool, kept in position by a special bandage. There are many types of this bandage, the best known being the Moorfield's pattern.

DIFFICULTIES AND COMPLICATIONS during the operation are

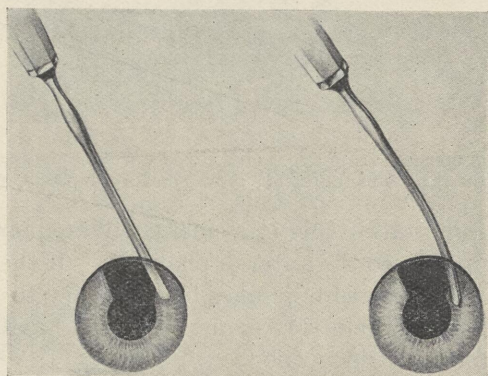


FIG. 178.—Reposition of iris (after iridectomy) by means of iris repositor.  
[Drawing by Hamblin.]

numerous, and may be due to faulty technique or to bad behaviour by the patient.

The principal ones are as follows.

(1) *Errors in the Section.*—The counter-puncture may be in the cornea when a corneal section is produced. The disadvantage of this is that a smaller opening is made for the escape of the lens, and that it is not usually possible to obtain a conjunctival flap. The counter-puncture may be in the sclera, producing a scleral section which entails two disadvantages: (a) The occurrence of hæmorrhage which flows into the anterior chamber, hiding the iris and lens from the operator's view; (b) the knife is nearly in the plane of the iris, so that the latter falls in the way of the knife, and a ragged portion of it may be excised, causing the patient pain, and making him squeeze.

The section may be too small, thus hindering easy escape of the



lens. The remedy, if the lens will not come out, is to enlarge the section with scissors.

(2) *Prolapse of vitreous* is usually due to the patient squeezing his lids together. If it occurs before the lens has been removed, its consequences are apt to be serious. A lens scoop (Fig. 179) must be passed into the eye, and be used for removing the lens, since an attempt to remove the lens in the ordinary way would only result in loss of more vitreous.

Prolapse of the vitreous after removal of the cataract is again

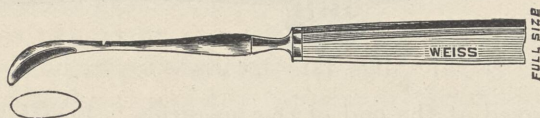


FIG. 179.—Lens scoop for extracting dislocated cataracts.

due to squeezing on the part of the patient. The eye must be gently closed and bandaged—no attempt being made to get the iris back into position. A subsequent operation may be needed to deal with the iris prolapse. These cases are not by any means hopeless, and some do quite well, especially when the vitreous is fluid.

(3) *Folding of the iris over the knife* may occur during the section. It is due to a variety of causes, the commonest being a premature escape of aqueous and the presence of a shallow anterior chamber. It is best dealt with by stroking the cornea over the

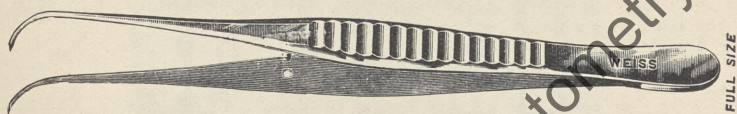


FIG. 180.—Iris forceps.

knife with an iris repositor (Foster Moore), which coaxes the iris back, so that the section can be completed without injuring it.

(4) If the *lens is not easily dislocated*, a cystitome (Fig. 174) must be introduced and used to lacerate the capsule more freely. If the pupil has not dilated well with homatropine and cocaine, or if there are any iris adhesions, a complete iridectomy (*vide p. 268*) should be performed before attempting delivery of the lens.

(5) *Expulsive hæmorrhage*, in which a large intraocular hæmorrhage occurs, usually in patients with high blood pressure. The result is expulsion through the wound of the lens, the vitreous, and sometimes part of the retina. The eye is, of course, irretrievably lost.



(6) During convalescence hæmorrhages may occur, but these are usually small and are soon absorbed.

**Cataract extraction with peripheral iridectomy** is performed in the same way as simple extraction, except that a small piece of

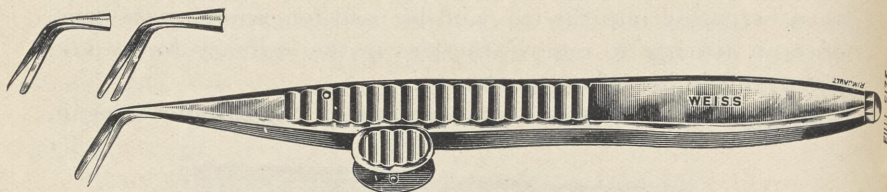


FIG. 181.—Iris scissors.

iris is removed at the end of the operation. For this purpose a pair of iris forceps (Fig. 180) is introduced between the lips of the wound, made to pick up a small knuckle of iris near the periphery, and to bring this out of the wound. The knuckle of iris is then

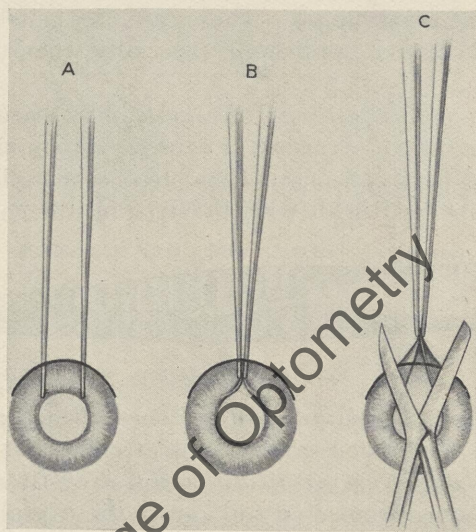


FIG. 182.—A, B, and C, Successive stages in iridectomy. [Drawing by Hamblin.

removed with iris scissors (Fig. 181), the blades of which are held tangential with the limbus. An iris reposer is then used to put the iris back into position. The result of this procedure is to leave a small coloboma of the iris above.

**Cataract Extraction with Complete Iridectomy.**—The section is made as already described, but without lacerating the lens



capsule. Iris forceps are then used to grasp the iris near its pupillary margin (Fig. 182, A) and bring it out of the wound (Fig. 182, B). The portion of iris held by the forceps is removed by iris scissors, held so that the blades point towards the operator, *i.e.*, so that they cross the limbus at right angles (Fig. 182, C). A cystitome is now introduced to lacerate the lens capsule and the cataract is expressed. Subsequent procedures are as already described.

It is usual to instil a drop of atropine at the close of the operation if iridectomy has been performed.

CHOICE OF OPERATION is regulated by various conditions, and the relative advantages of the three types of operation are set out below. A consideration of intracapsular extraction is outside the scope of this book.

#### SIMPLE EXTRACTION.

#### COMBINED EXTRACTION.

##### Complete Iridectomy.

##### Peripheral Iridectomy.

- |   |   |   |
|---|---|---|
| (1) Easier to perform.  | (1) More difficult to perform.  | (1) More difficult to perform.  |
| (2) Definite risk of post-operative iris prolapse.  | (2) Obviates almost entirely risk of post-operative iris prolapse.  | (2) Obviates almost entirely risk of post-operative iris prolapse.  |
| (3) Less danger of prolapse of lens capsule.  | (3) Risk of prolapse of lens capsule.   | (3) Less danger of lens capsule prolapse.   |
| (4) Fewer instruments enter the eye, therefore less risk of infection.  | (4) Longer operation, more instruments in the eye, may cause pain when cutting the iris, and loss of vitreous from patient squeezing. | (4) Iridectomy is done after extraction of lens, and pain may cause patient to squeeze and lose vitreous. |
| (5) With a rigid sphincter iridis, or in presence of iris adhesions, more pressure is needed to dislocate the lens, and consequently there is greater risk of loss of vitreous. | (5) Very useful with rigid pupil, or in presence of iris adhesions.   | —   |
| (6) No coloboma, and, in a favourable case, no external evidence of operation having been performed.  | (6) Coloboma visible after operation.   | (6) Coloboma usually hidden by upper lid.   |

From a consideration of the above, it will be seen that in favourable cases the operation of election is simple extraction. Moreover, pathological examination of eyes removed for infection following cataract extraction, shows in a majority of cases that

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the infection is due to the lips of the wound having been kept open by lens capsule which has prolapsed between them. Such a condition cannot occur if the iris is *in situ*, as the tags of capsule are not long enough to extend round the pupil margin and reach up to the wound in the limbus. Now lens capsule is transparent so that diagnosis of its prolapse is difficult, and treatment of the condition still more so. The iris, on the other hand, is easily visible, and abscission of prolapsed iris is not usually a difficult operation.

If at the conclusion of a simple extraction the iris does not go back easily into the anterior chamber, it is advisable to do a peripheral iridectomy, otherwise post-operative prolapse is almost bound to occur.



FIG. 183.—Ziegler's needle.

### DISCISSION OR NEEDLING

The operation is performed (i.) in the treatment of cataract in patients under the age of thirty; (ii.) for the removal of the lens in high myopes under the age of thirty; (iii.) in the treatment of after-cataract.

There are various types of needles; one, which is commonly used, is known as Ziegler's needle (Fig. 183).

**Discission for (i.) and (ii.) by Ziegler's Method.**—The pupil is dilated with atropine, the eye cocainised and a speculum inserted.

The eye is held with fixation forceps below, and the needle entered on the flat inside the limbus at the 12 o'clock position. The point is carried carefully downwards until it is just under the iris midway between the 4 and 5 o'clock positions. The handle is then raised, and rotated so that the point is made to enter the lens and pass through its entire thickness. By a combination of the movements of raising and withdrawing the handle, the knife needle is made to saw through the whole thickness of the lens along a line joining the 4.30 and 12 o'clock positions. When this incision is completed, the point of the instrument is again passed downwards, but this time to between the 7 and 8 o'clock positions, from where a similar incision is made, crossing the first one near the pupil margin above (Fig. 184). In this way a wide inverted V-shaped incision is made through the entire thickness of the lens.

**AFTER-TREATMENT.**—The eye is bandaged and kept under



atropine. The lens speedily swells up and becomes opaque, the opaque matter being slowly dissolved away by the aqueous during the ensuing weeks until, in favourable cases, a clear pupil is left.

**Complications.**—(i.) The intraocular tension may rise, though this complication is much less common when the operation is performed as described above, than it is when only the lens capsule is lacerated. The condition may yield to treatment by hot bathing, but if not, curette evacuation must be performed (*vide infra*). (ii.) Some of the lens matter may remain unabsorbed, or absorption may become very slow. This also demands the performance of curette evacuation.

**Curette Evacuation.**—Under cocaine anaesthesia a keratome incision 5 to 6 mm. long is made through the limbus above. A curette (Fig. 174) is now introduced into the anterior chamber, and some of the flocculent lens matter will escape with the aqueous. The remainder is washed out by introducing the nozzle of an irrigating apparatus (Fig. 177), and allowing normal saline at body temperature to run into the eye. A certain amount of manipulation of the nozzle is often necessary before all the opaque lens cortex can be got rid of. The iris is replaced, if necessary, with an iris repositor, atropine is instilled and the eye covered with a pad and bandage.

**Dissection for After-cataract.**—The object of this procedure is to make a clear gap in the thin membrane which often persists after cataract extraction.

The operation is performed under cocaine in a darkened room, light from a stand lamp at the side of the operating table being condensed on to the membrane by a lens held by an assistant. The pupil should be dilated. The needle is usually made to enter the eye at the limbus on the temporal side, and the point is carried slightly beyond the centre of the pupil before being made to engage the membrane. An incision may then be made in the latter by raising the handle of the knife needle and moving it either laterally or vertically.

The direction of the incision must be varied to suit the require-

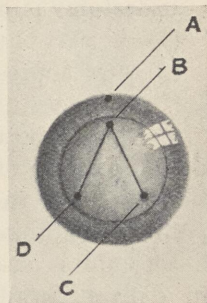


FIG. 184.—Needling by Ziegler's method. A, Point of entry through cornea. C, First puncture through lens. CB, First incision through lens. D, Second puncture through lens. DB, Second incision through lens, crossing first incision at B.



ments of the individual case. Thus if the membrane appears to be specially tense in the vertical direction, the incision should be horizontal, so that the edges will gape well. In some cases the membrane is very tough, and in these it must be cut through by a gentle sawing motion. Undue force must be avoided, as it may lead to damage of the iris and ciliary body.

**AFTER-TREATMENT.**—The eye is kept under atropine until all redness has disappeared. It usually suffices to keep the eye covered for twenty-four hours, especially if a small ice-bag is applied over the dressing for the first twelve hours.

**Iridectomy** is performed for various reasons :—

- (1) As part of the operation for cataract extraction (*vide* p. 268).
- (2) For acute glaucoma. It is then best performed under general anæsthesia, though in exceptional cases sub-conjunctival infiltration with novocaine may be used.

The position of the operator is the same as for cataract extraction, and the incision is best made with a Graefe knife. The point of the knife is made to enter the sclera  $1\frac{1}{2}$  mm. behind the limbus and is passed across the periphery of the anterior chamber in a plane parallel with that of the iris. The counter-puncture should be about 8 mm. distant from the puncture, the point of the knife emerging  $1\frac{1}{2}$  mm. behind the limbus. It is important to keep the point of the knife always in front of the iris and not in front of the pupil, or the lens may be injured. The knife is made to cut out as in a cataract operation, and a conjunctival flap is similarly formed.

**Excision.**—The iris forceps are introduced closed into the anterior chamber, and made to pick out a large fold of iris as in Fig. 182, A and B. The object of the operation, however, is to excise a large piece of iris as close as possible to the periphery. The scissors are therefore held parallel and close to the wound, which may even be slightly depressed by them. They are then made to sever only the lateral half of the iridial fold, after which the iris is drawn with the forceps still further towards the nasal side of the wound, thus pulling still more iris from the eye before the nasal side is finally severed.

The iris is replaced in exactly the same way as described in the cataract operation (*vide* Fig. 178), though the procedure is more difficult on account of the atrophic condition of the iris. Attempts at reposition must be continued until both sphincter margins are in place. Atropine is used after the operation and the after-treatment follows the lines laid down for cataract extraction. It



is usually advisable to keep the unoperated eye under eserine, even if it is not actually glaucomatous, as the excitement of the operation may precipitate an acute attack in it.

(3) **Optical iridectomy** is performed in the following circumstances: (1) For perinuclear (lamellar) lens opacities in young persons if sight is improved by dilatation of the pupil; (2) for central corneal scars; (3) for connective tissue membranes covering the pupil after iritis.

The object of the operation is to enlarge the pupil, so as to provide the patient with a clear area of cornea or lens, as the case may be, through which light may pass into the eye.

The site of election for the coloboma is the lower and inner quadrant, but in the corneal cases there is often no choice, as there may be only one area of clear cornea.

**TECHNIQUE.**—As a rule it is only necessary to remove that portion of iris which borders on the pupillary margin. The incision is therefore placed in the limbus or a little in the cornea. It is made with a bent keratome (Fig. 185). The point of this instrument is placed in the desired position, the handle being held between the thumb and first and second fingers, so that the blade forms an angle of about 60 degrees with the curvature of the sclera. The point is made to penetrate the limbus or cornea. As soon as it is seen in the anterior chamber, the direction of the knife is changed, so that the blade is parallel with the iris. The knife is then pushed onward until the incision is sufficiently large. Iris forceps are now introduced and a portion of iris excised, in the same way as already described in the operation of cataract extraction with complete iridectomy.

(4) Iridectomy may also be performed for annular and complete posterior synechiæ, for removal of cysts and foreign bodies embedded in the iris, and it is sometimes of service in preventing relapses in cases of chronic iritis.

### SCLERO-CORNEAL TREPHINING

This is the operation usually performed in this country for chronic glaucoma. It is done under local anæsthesia, and the steps are as follows:—

o.



Fig. 185.—Bent keratome.



A speculum is inserted and the patient directed to look down, the surgeon standing behind his head. A conjunctival flap is

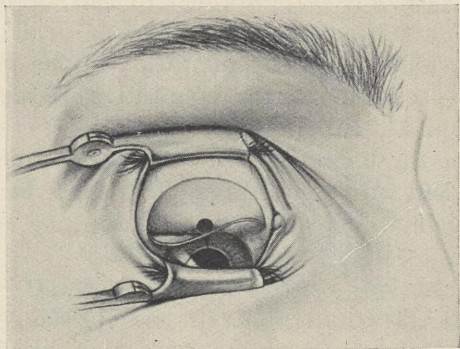


FIG. 186.—Sclero-corneal trephining. For the sake of clearness the flap has been made of much wider extent than is usually necessary. In practice, only about the middle third would be dissected up as far as the limbus. Note the trephine hole, the grey crescent of cornea and the small peripheral iridectomy.

dissected up to the limbus with scissors (Fig. 186) care being taken to make the flap as thick as possible when approaching the cornea.

When the limbus is reached, the flap is carefully held up by an assistant. The surgeon takes a Lang's knife (Fig. 187), and, holding the blade at an acute angle to the sclera, carefully splits the cornea for a distance of about 1 mm. It is important to work at exactly the right place, *i.e.*, just behind the line of reflection of the flap. If the knife is placed too far forwards, the conjunctiva is buttonholed; if too far back, all that happens is an ineffectual scratching of the sclera. When the cornea has been successfully split, the so-called "dark crescent" of cornea (Fig. 186) can be clearly seen.

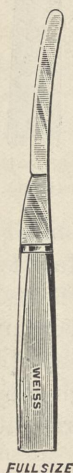


FIG. 187.—Lang's knife for splitting the cornea.

The flap is still held forwards, and a  $1\frac{1}{2}$ -mm. trephine (Fig. 188) held between the thumb and forefinger is applied as close as possible to it. It is essential to make the hole as far forward as possible, without buttonholing the flap. The trephine should therefore be carefully slid into place from the scleral side, the edge of the flap being carefully watched all the time. When the trephine is in place, it is held



with the upper end sloping a little towards the patient's feet. It is gently rotated between the thumb and forefinger, until it has cut through the corneo-sclera. When this occurs, the patient will feel a little pain, and his pupil will become oval in an upward direction. The assistant must therefore be on the watch for this, otherwise the trephine may pass too far into the eye and wound the lens.

The trephine is now removed. If it has been held in the correct direction, the surgeon will see

a little disc of sclera attached by a narrow hinge at its upper end, and pushed upwards by a black bead of prolapsed iris. The disc is picked up by a special pair of forceps (Fig. 189) and cut off at its "hinge" by a small pair of scissors held tangentially to the limbus; the iris is then grasped with a pair of iris forceps, and a small portion excised with iris scissors (Fig. 181) held in the same way. This results in the formation of a small V-shaped gap in the periphery of the iris, and the appearances will be as shown in Fig. 186.

All that remains now is to smooth the iris back into place by stroking the cornea with an iris repositor, and to secure the conjunctival flap with one or two sutures. A drop of atropine is usually instilled before the eye is finally closed.

Both eyes are covered, and the after-treatment follows the lines laid down for cataract operations.

**Prolapse of iris** is a condition which may follow a perforating wound of the eye, traumatic or operative. If left, the eye is almost certain to be lost.

FIG. 189. — Forceps for picking up the corneo-scleral disc.

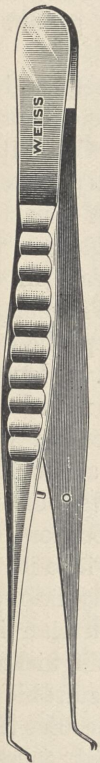


FIG. 188.—Sclero-corneal trephine.

The iris should be picked up with forceps, and an attempt made to loosen it from the edges of the wound by alternate traction, first on one side, then on the other. Iris scissors (Fig. 181) are then applied as close to the cornea as possible, the prolapsed portion of iris is abscised, and the edges of the coloboma are replaced with an iris repositor (Fig. 178).



If there is likelihood of infection, it is well to wash out the anterior chamber with warm hydrogen peroxide (diluted with saline to 3 volumes strength), followed by warm saline, and to put the patient on to full doses of hexamine.

**Perforating wound of the cornea**, if large, should be covered by a conjunctival flap. The simplest way of doing this is to incise and undermine the conjunctiva all the way round the limbus, as in the first stage of enucleation. A purse-string suture is then passed, and, when this is tied, the conjunctiva will come forward and cover the cornea completely.

The stitch may be removed in four or five days, when the conjunctiva will gradually retract.

**Paracentesis of the cornea** may be required in cases of temporary increase of intraocular pressure, *e.g.*, in acute iritis, and in cases where it is feared that a deep ulcer of the cornea will perforate.

The operation is best performed with a narrow keratome held almost vertically against the limbus below. When the point appears in the anterior chamber the plane of the blade is changed to that of the iris, and the keratome is pushed on. The incision should not exceed 3 mm. in length. The instrument should be carefully withdrawn to avoid escape of aqueous. The operator may now allow this to escape as slowly as he likes by gently depressing the scleral edge of the wound with an iris retractor. If too long an incision is made, the iris may prolapse into it.



Fig. 190.—Tattooing needles.

**Tattooing.**—Unsightly white scars of the cornea may be made to disappear almost completely by tattooing with Indian ink, since by this means they are made black, and so indistinguishable from the underlying pupil. Only solid flat scars are suitable for the operation, which is performed with a cluster of needles (Fig. 190). The cornea is kept covered with the Indian ink solution while the epithelium is pricked with the needles. Several sittings are usually necessary.

**Conical Cornea.**—Numerous operations have been devised for this condition. One of the most satisfactory is to apply a cautery at dull red heat, over a disc-shaped area about 3 mm. in diameter, having at its centre the apex of the cone. The cautery is applied lightly in the peripheral parts, and more deeply near the centre,



while at the actual centre it is made to perforate the cornea. A dense white scar results, optical iridectomy and tattooing being performed later.

**Cautery puncture** for detachment of the retina is carried out under local anæsthesia. It is advisable that the patient should be under the influence of omnopon or morphia, and scopolamine, in order to dull the discomfort produced by traction upon the extrinsic muscles in the extreme rotation of the eyeball which is necessary. The object of the operation is (1) to allow the escape of the fluid which separates the retina from the choroid external to it, and (2) to set up a localised mild inflammation in the coats of the eyeball at the site of the puncture of sclerotic and choroid by the galvano-cautery. The removal of the fluid allows the retina, in a suitable case, to regain to some extent contact with the choroid. The localised inflammation set up by the cautery causes the formation of fibrous adhesions between the two membranes and the sclerotic.

The site at which the puncture is made is determined by the position of the retinal detachment. In a particular case, let it be assumed that the cautery is to be applied between the external rectus and the inferior rectus muscles. The conjunctiva and the capsule of Tenon are incised radially between the tendons of insertion of the two muscles. The wound is widely opened by means of sutures inserted on each side of the wound and used as retractors. The eyeball must be elevated and adducted as far as possible. The sclerotic is freed of loose connective tissue and dried carefully, and is then punctured by the gentle application of a delicate electro-cautery at dull red heat a short distance *behind* the equator of the eyeball. The cautery point is made to pierce the choroid and, at once, by so doing, causes the escape of fluid. The escape of this fluid is encouraged by gentle pressure with gauze squares. The wound is closed by two sutures. The eye is bandaged with moderate pressure. It is usually necessary to repeat the operation in different parts of the eyeball once, twice, or even more times.

**Magnet.**—An electromagnet may be of great service in the extraction of iron and steel from the vitreous. The usual pattern is Mellinger's. It consists of a large coil of wire which by a suitable stand, can be arranged to encircle the patient's head as he lies on the operating table. Bars of soft iron of various size are supplied. One of these is held over the patient's eye, if possible at the wound of entry in the cornea. When the current



is switched on, the bar becomes magnetic and draws the metallic foreign body round the back of the lens into the anterior chamber. It can be extracted from here by a hand magnet, a keratome incision being made if necessary.

**Pterygium.**—If the pterygium is advancing over the cornea and approaching the pupillary region, it should be dealt with as follows :—

Cocainise the eye and insert a speculum. Pick up the “ neck ” of the pterygium in forceps and transfix it at the limbus with a Graefe knife held on the flat. Cut towards the centre of the cornea until the head is separated, then, with a pair of scissors, cut along the inferior margin of the body of the growth. Undermine the conjunctiva with scissors, above and below the incision. Pass both needles of a double-armed suture through the head of the pterygium from its under surface. Carry the needles under the conjunctiva forming the lower margin of the incision, to the region of the lower fornix, making them emerge about  $\frac{1}{4}$  inch from each other. Traction on the threads will now cause the head of the pterygium to glide under the conjunctiva. The suture is tied fairly tightly and the ends cut off. It may be removed in two days.



## CHAPTER XVI

### OPHTHALMOLOGICAL SIGNS AND SYMPTOMS OCCURRING IN GENERAL DISEASES

A CONSIDERABLE number of general diseases have already been discussed in the foregoing chapters, *e.g.*, the retinal changes in renal disease, arteriosclerosis, and diabetes, and the optic nerve changes in cerebral tumour. There remain, however, certain ophthalmic signs and symptoms which have a bearing on general disease.

#### I. NYSTAGMUS

This consists in a more or less rhythmical oscillation of the eyes. It may occur in any direction and be horizontal, vertical, rotatory or mixed. The movement may be uniform in speed or quicker in one direction than the other. It is almost invariably binocular, but occasionally it is limited to one eye. The frequency of the oscillations varies enormously in different cases.

**ÆTIOLOGY.**—Nystagmus may be considered under the headings of (i.) *physiological*, and (ii.) *pathological*.

(1) **Physiological.**—This is peripheral in origin, and the stimulus may be (a) *ocular*, or (b) *labyrinthine*.

(a) A familiar example of the former is furnished by "railway nystagmus." A passenger in a train, looking out of the window, follows the passing objects with his eyes, the slow movement of the eyes being against the direction of movement of the train, so as to keep the image of the objects at which he is looking on the macula. When his eyes have reached the limit of their horizontal excursion, they make a quick movement in the direction of motion of the train and pick up a fresh object, when the process is repeated. When the train stops there is, for a short period, a compensatory reverse movement of the eyes in which the quick component is against the direction of the previous motion of the train. A similar phenomenon occurs after rotation of a patient in a Barany chair, though it is thought that the stimulus in this case is labyrinthine.

(b) There is an intimate connection between the afferent paths from the labyrinths and the supranuclear centres of the oculo-



motor nerves. In the resting state, equal stimuli come from the two sides and neutralise one another, so that there is no resultant movement of the eyes. It is possible, however, by injecting hot or cold water into the external auditory meatus, to stimulate the semicircular canals on the same side. This gives the patient a feeling of being turned towards the stimulated side, and he develops a movement of the eyes as though he were actually being turned in this direction and were endeavouring to keep passing objects within his field of vision for as long as possible, *i.e.*, the quick component of the nystagmus is towards the stimulated side and in the direction of apparent rotation.

Another explanation is that the slow movement represents a forced movement of the eyes to the side opposite the labyrinth as a result of stimuli passing from it, the quick return movement being the result of reflex stimulus from the ocular muscles, due to their altered tension.

The absence of physiological nystagmus may thus be an important sign in labyrinthine disease or in disease of the central nervous system, which interferes with the ocular motor tracts or their connections with the labyrinth.

(2) **Pathological** nystagmus may be (A) *peripheral*, or (B) *central* in origin.

(A) *Peripheral*.—Here, again, the primary cause may be ocular or labyrinthine.

(a) *Ocular*. The fovea centralis is a highly specialised portion of the retina. It has been estimated, in an Emmetrope, that the region of the retina capable of reading Jäger 1 print is limited to an area round the fovea, which subtends an angle of less than 2 degrees at the nodal point of the eye.

Central fixation is therefore essential for good vision, and there is every incentive for an individual to keep his eye steady when looking at an object.

This highly specialised function of the fovea is developed during the early months of life and can seldom be acquired later. Hence, if anything happens to the eye which interferes with foveal vision in infancy, the function may not be developed and there is not the same incentive to keep the eyes steady. Examples of such conditions are dense corneal opacities left from ophthalmia neonatorum, faintly dense lens opacities, central choroido-retinitis, and, finally, amblyopia from disuse in squint. If the defect be monocular, as in the squint cases, the nystagmus does not usually occur unless the good eye is covered.



Another type of ocular nystagmus is the occupational variety, the commonest being that which occurs in miners. These men work under such reduced illumination that their eyes are "dark adapted." A dark adapted eye is relatively blind in the foveal region, the area of maximum vision being an annular area of the retina about 10 degrees from the fovea. There is, therefore, no one direction in which the eye can look and attain its maximum visual acuity. Moreover, the rapid formation of after-images favours continual movement of the eye in order to obtain as good vision as possible. Nystagmus develops in these circumstances and sometimes proves a serious disability, being associated with photophobia, apparent movement of objects, and defective vision. The actual cause of miner's nystagmus is not yet finally settled, some authorities ascribing it to neurasthenia, others to the presence of noxious gases in the pit, though the theory outlined above is that which has received the most general acceptance.

Albinism is another cause of ocular nystagmus. Here, again, the condition is probably due to impaired differentiation of the fovea.

A form of pseudo-nystagmus is often seen in extreme horizontal deviation of the eyes and is of no clinical significance.

(b) Labyrinthine. Any disturbance of the semicircular canals is likely to result in giddiness and nystagmus. In labyrinthine disease when there is irritation of one of the semicircular canals the conditions are similar to those already described as a result of artificial stimulation by cold or hot water, and the quick component of the nystagmus is towards the diseased side. Destruction of both labyrinths results in abolition of nystagmus, even after rotation in a B  r  ny chair. If only one labyrinth be destroyed, however, spontaneous rhythmic nystagmus occurs with the quick component towards the opposite side and persists for a short time. Should the opposite labyrinth be destroyed later there is a short period of nystagmus in the opposite direction.

(B) *Central*.—Here the cause is in the central nervous system, and the resulting nystagmus may be seen in the following diseases :—

(i.) Disseminated sclerosis. In the earlier stages of this disease a fine vibratory tremor of the eyes may be noticed during examination of the fundi with an ophthalmoscope. This "jelly-like" nystagmus, in conjunction with pallor of the temporal parts of the discs, is always highly suggestive of the disease. In



the later stages a different type of nystagmus occurs, the movements of which are much coarser. It is best elicited when the patient is asked to look towards the periphery in one or other direction. The condition is probably due to a failure in synergic action of the muscles, consequent on their unequal degree of innervation.

(ii.) Syringomyelia. In the early stages of the disease in about 10 per cent. of cases there is nystagmus. The cause is unknown.

(iii.) Friedreich's ataxia—in which nystagmus is an exceedingly common but late symptom. It is usually absent when the eyes are at rest and occurs on voluntary movement, especially in the horizontal plane.

(iv.) Cerebellar lesions, whatever their nature, nearly always give rise to nystagmus. The amplitude of the eye movements varies as the direction of gaze is altered. This variation may have a definite localising value, since the movements are coarse and slow when the eyes are directed towards the side of the lesion, and finer and more rapid when they are directed away from the lesion.

## II. VISUAL FIELD CHANGES

These are of frequent occurrence in disease of the central nervous system. An accurate record of the field may be of great importance in diagnosis. The occurrence of a central scotoma in disseminated sclerosis, retrobulbar neuritis, Leber's atrophy and toxic amblyopia has already been discussed (p. 201), also the changes in glaucoma (p. 210), tabes (p. 209), and diseases of the retina and choroid. Instructions for taking the field will be found on p. 14. The following points remain for discussion:—

(A) **Hemianopia** (*vel hemianopsia*).—This constitutes loss of sight in one-half of the field of vision, usually in both eyes. The loss may be *absolute*, when even white objects cannot be perceived, *relative* when the object can be seen, but only dimly or when there is loss of colour perception only, with ability to distinguish white objects. The commonest type of defect is that in which the dividing line between the blind and seeing portions is vertical and the corresponding halves of the two fields—right and left—are lost. This condition is known as *homonymous hemianopia* (Fig. 104). Another variety, which is less common, is known as *bi-temporal hemianopia*. In this there is a loss of more or less of the temporal portion of the field in each eye. *Binasal hemianopia* is such a rarity as to be almost unknown. If the dividing



line be horizontal instead of vertical, the condition is known as *altitudinal hemianopia* and is very rare.

Hemianopia may be caused by a lesion at the chiasma or at any point in the course of the visual fibres between this structure and the occipital cortex. The course of these fibres is given in Fig. 192, p. 285.

The cortical representation of the field of vision in the lips of the calcarine fissure has been carefully worked out by studying the effect of injuries. It was found that the macular region was represented in the cortex lying at the tip of the occipital pole, the portion lying above the calcarine fissure corresponding with that part of the field which lies below the fixation point and *vice versa*.

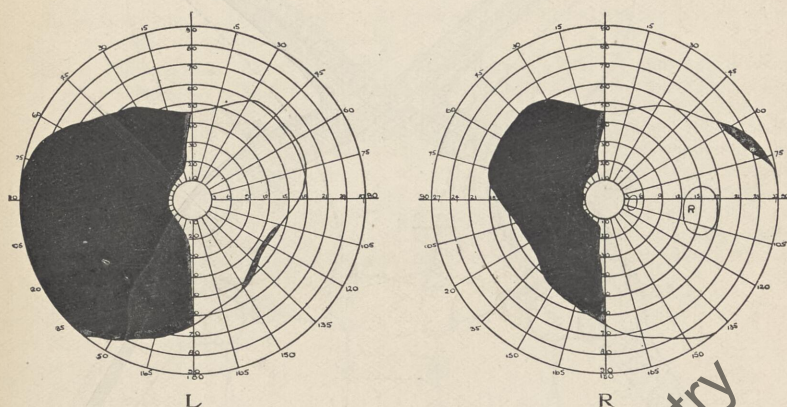


FIG. 191.—Left hemianopia due to vascular lesion. The dark area indicates the blind portion of field. Note "sparing" of macular region.

The more peripheral the portion concerned the further from the occipital pole was its cortical representation. Also, the further a given area of field was from the horizontal meridian the further its cortical representation was from the bottom of the calcarine fissure.

Localisation of the lesion is of great practical importance, especially when surgical treatment is contemplated. The following points are of value :—

(1) CHIASMAL LESIONS.—The chiasma is the only part of the optic tract where a single lesion can bring about bi-temporal hemianopia, the commonest cause being enlargement of the pituitary gland. Other less common causes are sphenoidal sinus disease, basal meningitis, usually syphilitic, and occasionally fractures of the base of the skull.



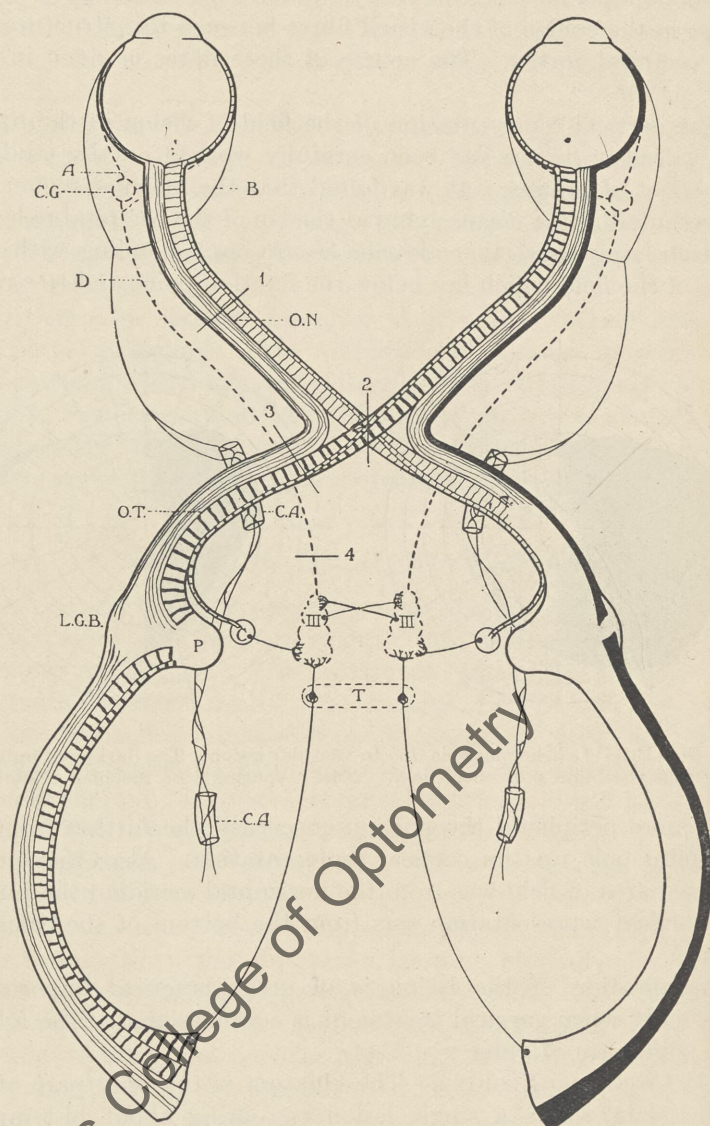


FIG. 192. Drawing by Hamblin.



FIG. 192.

Scheme to illustrate the visual paths from the retina to the occipital pole (modified from Whitnall), and the pupillary reflex paths (cf. Fig. 112).

The temporal or direct and the nasal or crossed visual fibres, and their connections *via* the lower visual centres with the cortex, are indicated by hatching. It is not intended to intimate that any particular band of fibres of optic nerve or tract ends in any particular one of these centres.

L.G.B. = the lateral geniculate body,

P. = the pulvinar,

C. = colliculus superior or anterior corpus quadrigeminum through which the retina is connected with the nuclei of the nerves supplying the muscles of the eyeball (III., IV. and VI. The IIIrd nucleus alone is shown),

T. = tegmentum, through the cells of which the visual cortex is connected with the third nerve nuclei,

III. = third cranial nerve nucleus. The efferent path of the pupillo-constrictor reflex, from the anterior part of the oculo-motor nucleus (III.) *via* the ciliary ganglion (C.G.) to the sphincter iridis, is indicated by the interrupted line. The pupillo-dilator reflex passes from the cilio-spinal centre in the lower cervical and upper thoracic segments of the spinal chord by the rami communicantes to the first thoracic sympathetic ganglion; then by the cervical sympathetic to the plexus on the internal carotid artery (C.A.), and so to the Gasserian ganglion; thence by the first division of the Vth cranial nerve and its nasal branch, and by the long ciliary nerves (B.) to the iris,

A. = short ciliary nerve,

B. = long ciliary nerve,

D. = oculo-motor nerve,

O.N. = optic nerve,

O.T. = optic tract.

EXPLANATION OF LESIONS (see numbers in figure).

1. *Section of Left Optic Nerve.*—Left fundus illumination gives no reaction of left pupil, and no consensual reaction of right. Right fundus illumination constricts both pupils. Left eye blind.

2. *Sagittal Section of Chiasma.*—Pupils equal. Either pupil illuminated = constriction of both (connections of oculo-motor nuclei in floor of fourth ventricle). Bitemporal hemianopia (blindness of nasal half of each retina), and Wernicke's hemiopic pupillary reaction present (pupil constriction follows illumination of temporal halves of retinae, but not of nasal halves).

3. *Section of Left Optic Tract.*—Pupils equal. Right homonymous hemianopia. Wernicke's hemiopic pupillary reaction present (illumination of right-sided halves of retinae gives pupil constriction; no reaction with left-sided stimulation).

4. *Section of Left Oculo-motor Nerve* (or lesion of its nucleus). Left-sided pupil dilatation and paralysis of accommodation. Left pupil reacts only to sympathetic stimulation.



Since pituitary enlargement is seldom symmetrical, it is unusual to find a symmetrical loss of field, and in some cases there may be a marked loss of field in one eye before the other is affected. In the early stages of the disease very careful examination with small objects is necessary in order to detect the loss of field, which usually begins as a slanting defect in the upper temporal region (*vide* Fig. 193 for fields in a typical case of early pituitary disease).

The rare cases of altitudinal hemianopia may also have their origin in a lesion of the chiasma, being caused by pressure on

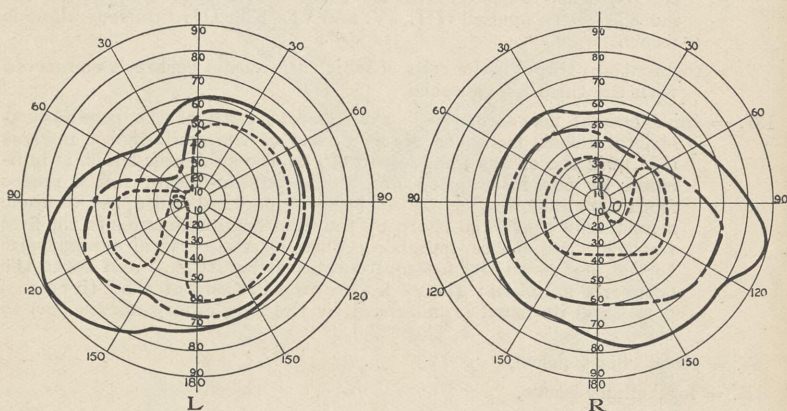


FIG. 193 (after Walker).—Field loss in case of pituitary disease. Unbroken line = limit of field for object subtending 1 degree. --- = limit of field for object subtending  $\frac{1}{2}$  degree. . . . = limit of field for object subtending  $\frac{1}{16}$  degree. Note comparatively small field loss with 1-degree object. This shows necessity of using small objects.

this structure from above or below. Some of these cases, however, are cortical in origin and not chiasmal.

(2) TRACT LESIONS, if complete, cause complete hemianopia of the opposite side. If the lesion be situated between the chiasma and the point where the afferent pupillo-motor fibres leave the tract to pass to the superior colliculus, Wernicke's pupil reaction (*vide* p. 285) may be present. In practice, however, this reaction is very difficult to elicit, and some authorities deny its existence, so that its localising value is very slight. If the lesion be on the proximal side of the point where the pupillo-motor fibres leave the tract the fibres will not be involved and therefore there will be no difference in the pupil reaction on illumination of the blind and seeing parts of the retina respectively.



(3) VASCULAR LESIONS are among the commonest causes of hemianopia, and present the following general characteristics :—

(a) The line separating the blind and seeing portions of the field skirts the macular area, passing, as a rule, between the 10 and 15 degree circles ("sparing of the macula," *vide* Fig. 191). When the lesion is cortical this can be explained by the fact that the macular area of cortex is supplied by branches from both the middle and posterior cerebral arteries, so that if the supply of blood is cut off from one artery the other will still function. Even in bilateral lesions producing "double hemianopia," vision is still retained within the central 10 degree and 15 degree circles. In traumatic lesions this sparing of the macula is not observed.

(b) The loss of field remains unchanged and recovery does not occur.

The blood supply of the optic paths, behind the chiasma, is as follows :—

(i.) *The anterior choroidal artery*—a branch of the middle cerebral—supplies the optic tracts, part of the external geniculate body and the commencement of the optic radiations.

(ii.) *The middle cerebral* supplies the remainder of the optic radiations until the latter approach the calcarine fissure. It also shares in supplying the macular region of the occipital cortex.

(iii.) *The posterior cerebral* is the principal artery of supply for the visual cortex.

A lesion of any one of these arteries may bring about a complete or partial hemianopia of the opposite side, and various syndromes are associated with blockage of the different vessels (Schiff Wertheimer). Thus, in addition to the hemianopia, a lesion—

(i.) Of the anterior choroidal artery causes contra-lateral hemiplegia and hemianæsthesia without coma, also without aphasia, even if the lesion be on the left side.

(ii.) Of the middle cerebral artery, if complete, is usually incompatible with life. If only the deep branch be involved hemianopia does not usually occur. If only the superficial branch, hemianopia occurs, with contra-lateral hemiplegia, having a spasmodic tendency especially in the upper limb. If the lesion be on the left side there is aphasia and sometimes apraxia.

(iii.) Of the posterior cerebral artery, causes the "thalamic syndrome" description of which is outside the scope of this book, and if the lesion be on the left side some aphasia and often alexia. Softening of any part of the area supplied by this vessel



will bring about a partial or a quadrantic hemianopia. The lesion involves most commonly the inferior lip of the calcarine fissure so that the commonest situation for loss of field is in the upper quadrant. In some cases the scotoma is quite small, homonymous and paracentral in position, being then due to a lesion occurring in one of the minute terminal branches of the posterior cerebral artery.

It should be noted that 70 per cent. of cerebral vascular lesions occur in patients already the subject of retinal arterio-sclerosis. The fundus appearances may therefore be a determining factor in the diagnosis.

(4) **HEMIANOPIA DUE TO "TUMOURS."**—This term includes granulomata, such as those produced by tubercle and syphilis, as well as actual neoplasms, *e.g.*, endothelioma and glioma.

If the hemianopia depend upon a cortical lesion, it is unaccompanied by hemiplegia, motor aphasia, or paralysis of the cerebral nerves as direct symptoms, though these may be present as "distant" symptoms.

Tumours of the temporo-sphenoidal lobe often produce a homonymous quadrantic hemianopia usually partial. According to Cushing this is due to involvement of some of the fibres of the optic radiation which loop round the lateral ventricle in this part of the brain.

There are many other factors to be considered in the localisation of tumours producing hemianopia, but they are of general neurological interest.

In conclusion, it may be said that left homonymous hemianopia produces less difficulty in reading than does right because we read from left to right, and in the latter condition the word immediately following that which is being looked at cannot be seen, whereas in left homonymous hemianopia it can be.

(B) **Asymmetrical Losses of Field.**—Apart from local disease in the eye, these occur in lesions affecting the optic nerves in front of the chiasma, some of which have been already considered under the headings of retrobulbar neuritis and toxic amblyopia. In addition to these, however, asymmetrical losses of field are found in—

(i.) *Tubes*, where the fields may be of almost any shape, though, in general, they may be grouped under two headings according to whether the parenchymatous or interstitial tissue of the nerve is primarily attacked. In the former event visual acuity is markedly diminished, while the field shows a comparatively small amount



of contraction. In the latter event the field may be markedly contracted and yet the patient retain good visual acuity. Mixed forms are, of course, also encountered. The appearances of the discs in tabes have been already described on p. 206.

(ii.) *Tumours causing Pressure on the Optic Nerve.*—Such pressure may be exerted by tumours of the frontal or temporo-sphenoidal lobes, and also by pituitary growths when they are asymmetrical and grow forwards. In these cases there may be partial or complete loss of field in one eye, with little or no change in the other. The pressure on the nerve causes a descending atrophy and, at the same time, shuts off the communication between the subdural space of the nerve and that of the brain. Ophthalmoscopically, therefore, one may find a “primary” optic atrophy on the side of the growth, with papillœdema in the other eye.



## CHAPTER XVII

### THERAPEUTICS

MANY eye diseases are manifestations of some form of general disease and are therefore not curable by local measures alone. A detailed description of the treatment of systemic disease is outside the scope of this book. A few points, however, may be mentioned which have a special bearing on ophthalmology.

#### SYSTEMIC TREATMENT

(1) **Syphilis.**—A full course of treatment with arsenical preparations and mercury is always advisable. Even in congenital cases, *e.g.*, interstitial keratitis, it has now been established that better results are obtained when arsenical preparations are given as well as mercury. In tertiary lesions in adults, iodides may be required in very large doses, *e.g.*, gr. xxx of potassium iodide three times daily.

(2) **Tubercle.**—Tuberculin has a very definite place in the therapy of the ocular manifestations of this disease—in addition, of course, to the usual treatment by fresh air and suitable diet. Opinions vary as to the most satisfactory type of tuberculin. In our hands bacillary emulsion (B.E.) has given good results. The initial dose should be  $\frac{1}{250,000}$  mg. Injections may be given twice a week, the dose being doubled each time, until a slight reaction is produced. When this point is reached, the next injection should be a little smaller, after which the amount is again cautiously increased, our aim being to give the patient a dose just short of what will produce a reaction.

(3) **Gonorrhœa.**—Here, again, vaccine therapy may be of great service in helping to eliminate infection in the iris or ciliary body, though its effect on conjunctival infections is not so satisfactory. In men a chronic prostatitis, and in women a chronic cervicitis, is usually present and requires adequate local treatment.

(4) **Focal Infection.**—May be the cause of a variety of ocular lesions, *e.g.*, keratitis profunda, episcleritis, chronic irido-cyclitis, choroiditis, etc. The diagnosis of the source of infection may be a matter of great difficulty, and it is well to have some sort of



routine method, of which the following is an example, the structures being examined in the order mentioned until a possible source of infection is found : (a) *Teeth*, externally and by X-ray (to exclude the presence of apical necrosis). (b) *Naso-pharynx*, especially the tonsils and accessory sinuses. (c) *The gastro-intestinal tract*, by bacteriological examination of the fæces for the presence of pathogenic organisms, by ordinary clinical methods, aided if necessary by a barium meal and X-ray for the presence of intestinal stasis, chronic appendicitis, etc.; (d) *The genito-urinary tract*, special attention being paid in men to the condition of the prostate and in women to the condition of the vagina and cervix. Bacteriological examination of a catheter specimen of urine is often advisable. With regard to treatment of the condition found, one aims at removal of the focus of infection whenever possible (e.g., extraction of the teeth, enucleation of tonsils, amputation of the cervix). In cases such as intestinal stasis, colonic lavage by the Plombières method, the administration of vaccines, regulation of diet and the use of a supporting belt may be of great service.

(5) **Arterio-sclerosis** is frequently discovered first by examination of the eye, the same being true of renal disease and diabetes. The treatment of these conditions is outside the scope of this book.

(6) **Non-specific Methods of General Treatment.**—(a) *The administration of arsenical antisyphilitic preparations.* Even in the absence of syphilis, a course of four or six injections of N.A.B. or some such preparation may be of the greatest service in the treatment of chronic irido-cyclitis or choroiditis of doubtful ætiology, and in sympathetic ophthalmia. (b) *The production of artificial pyrexia by protein shock* is sometimes of benefit in chronic inflammatory conditions. It is particularly useful in the treatment of obstinate phlyctenular keratitis and gonorrhœal ophthalmia. The best substance to use is milk which has been allowed to stand in a jug for twelve hours or so. Before use the milk is poured into a test tube, which is placed in a water bath kept at the boil for four minutes. When the milk has cooled down a dose of 10 c.c. (in an adult) is injected intraglutally. A sharp rise of temperature follows. The injection is repeated every three days. It is usually advisable to continue the treatment until there is no rise of temperature after an injection. (c) *Artificial sunlight* is of service as an accessory to other treatment in iritis and irido-cyclitis, in phlyctenular keratitis, infective choroiditis and tuberculous infec-



tions. With one type of mercury vapour lamp, the initial dose is two and half minutes exposure front and back at a distance of 3 feet from the lamp, the eyes being protected with goggles. Treatment should be given at three-day intervals, and the length of exposure increased by one minute each time. (*d*) *Hot air baths* are used as part of the treatment for acute uveitis and detached retina. The bath consists of a cradle into which are fitted a number of electric lamps. The patient is in bed and the cradle is placed over him, being covered with a mackintosh and blankets. The lamps are turned on for half an hour, or until the heat is too much for the patient to stand. He is then wrapped in blankets and allowed to perspire. The baths are given at intervals of two or three days. Perspiration is usually not free until the second or third bath.

### LOCAL TREATMENT

1. **Bathing.**—The best way of performing this is with an undine (Fig. 177), which is filled with the required lotion at body temperature. It is better to have the patient lying down; if he is sitting, his head should be well back. The lower lid is everted and a stream of lotion directed on to the exposed conjunctiva; then the upper lid is treated similarly (*vide* p. 5 for directions on how to evert the lids), and finally the edges of the lids are mopped gently with cotton-wool swabs wrung out of the lotion. In the absence of an undine the lotion may be applied to the conjunctiva of the everted lids by squeezing out swabs of cotton wool which have been soaked in it.

If the patient has to do the bathing himself it is usual to employ an eye cup. The following prescriptions represent a few of the many varieties of lotions used. In each case the lotion should be mixed with an equal quantity of hot boiled water unless otherwise stated.

#### Boric Acid Lotion.

Acid boric . . . . .	℥ij
Aq. dest. . . . .	ad ℥viii

For mild cases of conjunctivitis. The following, however, are usually more effective :—

#### Boric and Witch-hazel Lotion.

Acid boric . . . . .	℥ij
Aq. hamamelidis dest. . . . .	℥j
Aq. rosæ trip. . . . .	℥ij
Aq. dest. . . . .	ad ℥viii



**Boric and Glycothymoline Lotion.**—As above, but substitute glycothymoline  $\text{℥ij}$  for the liq. hamamelidis dest.

**Boric and Zinc Lotion.**

Acid boric . . . . .	$\text{℥i}$
Zinc sulph. . . . .	gr. vi
Aq. laurocerasi . . . . .	$\text{℥ij}$
Aq. dest. . . . .	ad $\text{℥xii}$

Useful for angular conjunctivitis; should be used cold and undiluted.

**Biborate Lotion.**

Sodii biborate . . . . .	gr. xxiv
Sodii bicarb. . . . .	gr. xvi
Sodii chloride . . . . .	gr. xxxii
Aq. camphoræ . . . . .	$\text{℥iij}$
Aq. dest. . . . .	ad $\text{℥viii}$

A bland unirritating lotion, isotonic when mixed with an equal quantity of water. Very useful for sensitive patients who cannot tolerate astringent lotions.

**Acetic Acid Lotion.**

Acid acetic dil. . . . .	$\text{℥iv}$
Aq. dest. . . . .	ad $\text{℥viii}$

**Carbolic Acid Lotion.**

Acid carbolic . . . . .	gr. xxii
Aq. dest. . . . .	ad $\text{℥viii}$

Either of these lotions is useful for allaying irritation in spring catarrh.

**Quinine Lotion.**

Quinine hydrochlor : . . . . .	gr. xxxii
Aq. dest. . . . .	ad $\text{℥viii}$

Used in treatment of dendritic ulcers and in superficial punctate keratitis.

**Salicylate Lotion.**

Sodii salicyl. . . . .	gr. xl
Acid salicyl. . . . .	gr. j
Aq. dest. . . . .	ad $\text{℥viii}$

Used in gouty conjunctivitis and in episcleritis.

**Hydarg. Perchlor. Lotion.**

Hydarg. perchlor. . . . .	gr. j, gr. $\frac{1}{2}$ or gr. $\frac{1}{4}$
Aq. dest. . . . .	ad $\text{℥viii}$



**Eusol Lotion.**

Eusol	.	.	.	.	.	℥j
Aq. dest.	.	.	.	.	.	℥viii

Both these lotions are of service in treatment of ophthalmia neonatorum and in gonococcal conjunctivitis. They should be used copiously with an undine, cold and undiluted, since cold inhibits the growth of the gonococcus.

**Alum and Boric Acid Lotion.**

Pulv. aluminis	.	.	.	.	gr. xxx
Acid boric	.	.	.	.	℥ij
Glycerine Croci (Squire)	.	.	.	.	℥ij
Aq. rosæ trip.	.	.	.	.	℥ij
Aq. dest.	.	.	.	.	ad ℥viii

A useful astringent lotion, contra-indicated if there are corneal ulcers, on account of the alum.

**Bicarbonate Lotion.**

Sodii bicarb.	.	.	.	.	℥j
Lig. carbonis det. (Wright)	.	.	.	.	℥j
Aq. dest.	.	.	.	.	ad ℥viii

Used for removal of crusts in blepharitis before applying the ointment.

**Ammonium Tartrate Lotion.**

Neutral ammonium tartrate, 10 per cent. in distilled water.

Used for lime burns of the cornea. The eyes should be bathed with the lotion warm and undiluted for fifteen to thirty minutes three or more times daily. At first the lotion causes a good deal of pain, and preliminary instillation of cocaine is necessary.

2. **Instillation of Drops (guttæ)** is done with a pipette, which may be incorporated in the stopper of the bottle, as in Chalk's bottle, or be separate. The pipette should be boiled periodically. It is usual to instil drops inside the lower lid, the lid being held down while the patient is directed to look up. Drops are used for the following purposes.

**(a) Anæsthetic Cocaine Drops.**

Cocaine hyd.	.	.	.	.	gr. j to gr. v
Acid boric	.	.	.	.	gr. iv
Aq. dest.	.	.	.	.	ad ℥ij

This is the most commonly used anæsthetic, the proportion of cocaine being varied to meet the needs of the case. Should the eye be congested the anæsthetic action is impaired, but is greatly



aided by the use of adrenalin in the last instillation of drops before an intraocular operation. A useful sterilised preparation for this purpose is put up in ampoules. Cocaine has a deleterious effect on the corneal epithelium; the eyes therefore should be kept closed in the intervals between repeated instillations. Cocaine also dilates the pupil by stimulation of the sympathetic nerve supply to the dilator pupillæ muscle. It must on this account be used with care in actual or suspected glaucoma, a myotic being available in case of need. The following preparations have the advantage of not causing dilatation of the pupil.

#### Alypin Drops.

Alypin	.	.	.	.	gr. ij
Acid boric	.	.	.	.	gr. iv
Aq. dest.	.	.	.	.	ad 3ij

#### Holocaine Drops.

Holocaine hyd.	.	.	.	.	gr. j
Aq. dest.	.	.	.	.	3ij

This solution must be very carefully prepared. The presence of any alkali will throw down the base.

#### (b) Mydriatic.—Atropine Drops.

Atropine sulphate	.	.	.	gr. $\frac{1}{4}$ , $\frac{1}{2}$ , or ij
Aq. dest.	.	.	.	3ij

The strength is varied to suit requirements. As a cycloplegic in children it is used in the strength of 1 per cent. (gr.  $\frac{1}{4}$  in Aq. 3ij), three times daily for three days. In iritis it may be used up to 2 per cent. In these cases, however, it is usually better to instil adrenalin and then use an atropine lamel or atropine ointment (*vide infra*). The same is true of interstitial keratitis if the cornea is highly vascularised. Atropine must never be used in actual or suspected primary glaucoma. In some cases, after more or less prolonged use, the patient develops atropine irritation, shown by the occurrence of an eczematous condition of the lids. Zinc oxide ointment or calamine lotion should then be applied to the lids and one of the other mydriatics substituted for the atropine, though after prolonged use they may also give rise to irritation.

#### Duboisine Drops.

Duboisine sulphate	.	.	.	gr. $\frac{1}{4}$
Aq. dest.	.	.	.	3ij

This rarely produces irritation, but it is more toxic than atropine and must be very carefully used.



**Homatropine Drops.—**

Homatropine hydrobromide . . . . .	gr. j or ij
Aq. dest. . . . .	℥ij

Homatropine has the advantage that it can be neutralised by eserine, whereas atropine cannot. It is therefore a useful mydriatic where there is a risk of glaucoma ensuing as result of dilatation of the pupil; the effect passes off in twenty-four hours. When the drug is to be used as a cycloplegic it is more effective if combined with cocaine.

**Homatropine and Cocaine Drops.**

Homatropine hydrobromide . . . . .	gr. ij
Cocaine hydrochloride . . . . .	gr. ij
Aq. dest. . . . .	℥ij

Three instillations are required at five-minute intervals one hour before examination. If the oily preparation is used (*vide infra*) one instillation suffices.

**Hyoscine or Scopolamine Hydrobromide Drops.**

Hyoscine hydrobromide . . . . .	gr. $\frac{1}{2}$
Aq. dest. . . . .	℥ij

This is a useful alternative to atropine in cases of atropine irritation. It is more toxic, but it is said to be a more powerful mydriatic.

**(c) Myotic.—Eserine Drops.**

Physostigmine sulphate . . . . .	gr. $\frac{1}{8}$ to 1
Acid boric . . . . .	gr. j
Aq. dest. . . . .	℥ij

**Eserine and Cocaine Drops.**

Physostigmine sulphate . . . . .	gr. $\frac{1}{4}$
Cocaine hydrochloride . . . . .	gr. j
Aq. dest. . . . .	℥ij

Eserine is a powerful myotic and is largely used in the non-operative treatment of glaucoma. The addition of cocaine renders it more effective, and diminishes the pain in the forehead and eye which frequently occurs after use of the simple preparation. The solution becomes pink after it has been kept for some time. This does not diminish its efficacy, though it makes it more irritating to the eye. Eserine also stimulates the ciliary muscle and helps in restoring accommodation after cycloplegia.



**Pilocarpine Nitrate Drops.**

Pilocarpine nitrate . . . . .	gr. $\frac{1}{2}$ or j
Aq. dest. . . . .	$\bar{3}$ ij

A less powerful myotic than eserine, but does not produce pain or irritation. It has been used in strengths up to 3 per cent. without producing toxic symptoms.

**(d) Stimulant.—Argyrol Drops.**

Argyrol . . . . .	gr. x to lx
Aq. dest. . . . .	ad $\bar{3}$ ij

Very useful in the treatment of conjunctivitis (*q.v.*). It is less powerful but less irritating than silver nitrate. When painted on the lids it may be used in 40 per cent. solution, but if prescribed as drops the 10 per cent. solution (gr. x in aq. dest.  $\bar{3}$ ij) is usually employed. It should not be used continuously for longer than a fortnight or argyrosis may ensue.

**Copper Sulphate Drops.**

Cupri sulph. . . . .	gr. $\frac{1}{4}$ or gr. $\frac{1}{2}$
Aq. dest. . . . .	ad $\bar{3}$ ij

Useful in mild trachoma, where the inflammation is not sufficiently severe to warrant the daily application of copper sulphate stick.

**Dionine Drops.**

Dionine . . . . .	gr. 1 to j
Aq. dest. . . . .	$\bar{3}$ ij

Produces marked œdema of the bulbar conjunctiva and increase in the lymph supply of the cornea. It is employed for this purpose in the treatment of various corneal conditions, particularly opacities. The drug soon loses its effect and should only be used every two or three days. The strength has to be gradually increased until eventually the solid drug may be required to produce a reaction.

**Ethyl Hydrocuprein (vel optochin) Drops.**—Ethyl hydrocuprein hydrochloride, 1 or 2 per cent.

Used in treatment of pneumococcal ulcers of the cornea. It is applied directly to the ulcer by a swab three times daily and causes a burning pain for five to ten minutes, followed by anæsthesia. The effect is maintained by instilling a drop of 1 per cent. optochin hourly during the day and using it as a 1 per cent. ointment in combination with atropine at night.



**Fluorescein Drops.**

Fluorescein.	.	.	.	.	gr. iv
Sodii bicarb.	.	.	.	.	gr. iv
Aq. dest.	.	.	.	.	℥ij

Used in the diagnosis of corneal ulcers and abrasions, which it stains green. Can be obtained sterilised, in capillary glass tubes ready for immediate use.

**Hydrarg. Perchlor. Solution.**

Hydrarg. perchlor.	.	.	.	.	gr. $\frac{1}{3}$ to gr. j
Glycerine	.	.	.	.	℥ij

Applied to the conjunctiva after the operation of expression for trachoma.

**Protargol Drops.**

Protargol	.	.	.	.	gr. iv to xx
Aq. dest.	.	.	.	.	℥ij

Used in the same way as argyrol.

**Silver Nitrate Solution.**

Argent. nit.	.	.	.	.	gr. $\frac{1}{4}$ to ij
Glycerine puriss.	.	.	.	.	℥xii
Aq. dest.	.	.	.	.	ad ℥ij

Used in varying strengths for painting on the everted lids in conjunctivitis. Should never be prescribed as drops for the patient to use himself.

**Zinc Sulphate Drops.**

Zinc sulphate	.	.	.	.	gr. $\frac{1}{4}$
Acid boric	.	.	.	.	gr. ij
Aq. laurocerasi	.	.	.	.	℥xxx
Aq. dest.	.	.	.	.	ad ℥ij

Used in the treatment of angular conjunctivitis. Generally ordered to be dropped into the eye after bathing with a lotion such as boric and witch-hazel (*vide supra*).

**Oily Solutions.**—The advantage of these is that the action of the drug in an oily vehicle is more prompt and lasting than when it is in a watery solution, since it cannot so easily be washed away by lacrymal secretion. A disadvantage, in refraction work, is that the oil may form a thin film over the cornea, which interferes with retinoscopy and subjective testing. This can be avoided by using only a small quantity of the preparation.



**Eserine Oil.**

Physostigmine . . . .	gr. j
Cocaine alkaloid . . . .	gr. ij
Oil ric. puriss. . . . .	℥j
Ol. amygdalæ . . . . .	ad ℥ij

Very useful in congestive glaucoma where there is a good deal of lacrymation. Also useful for neutralising the effect of homatropine. Employed in lower concentration (*e.g.*, gr.  $\frac{1}{8}$  in ℥ij) in chronic glaucoma if the watery solution causes conjunctival irritation.

**Homatropine Oil.**

Homatropine alkaloid . . . .	gr. ij
Cocaine alkaloid . . . . .	gr. ij
Ol. ric. puriss. . . . .	℥ij

Largely used in refraction. One instillation in each eye is sufficient to produce cycloplegia in an hour.

**3. Application of Ointments.**—Some of these are conveniently dispensed in small collapsible tubes with a fine nozzle. A portion of ointment about  $\frac{1}{4}$  inch long may then be expressed into the lower conjunctival cul de sac. When the ointment is not in a tube, a glass rod should be ordered with which to place a portion of ointment about the size of a match-head inside the lower cul de sac.

**Atropin Ointment.**

Atropin (base) . . . . .	gr. $\frac{1}{2}$ to 2
Vaseline flav. puriss. . . . .	℥ij

Useful for producing cycloplegia in children where there is difficulty in instilling watery drops; also a convenient method of employing atropine in iritis, keratitis, etc.

**Boric Acid Ointment.**

Pulv. acid boric . . . . .	gr. xv
Paraffin moll. alb. . . . .	℥ij

Used at night in the treatment of conjunctivitis to prevent adhesion of the lids. Boric vaseline is also used for the same purpose. Both preparations have the advantage of being bland and unirritating.

**Copper Citrate Ointment.**

Cupri citratis . . . . .	gr. v
Paraffin moll. . . . .	℥ij

Used in trachoma as an alternative to copper sulphate drops.



**Mercurial Ointments.**

- (1) Ung. hydrarg. nit. 1/10 B.P. strength.

Used in the treatment of blepharitis, when it should be massaged into the roots of the lashes after crusts have been removed with bicarbonate lotion.

- (2) Ung. hydrarg. ammon. dil.

Hydrarg. ammon.	gr. ij
Vaseline flav.	℥ij

This is used as an alternative to ung. hydrarg. nit. dil.

- (3) Ung. hydrarg. ox. flav.

Hydrarg ox. flav.	gr. j
Liq. calcis	℥ij
Vaseline flav. puriss.	℥ij

The mercuric oxide must be freshly precipitated and as free from moisture as possible. The preparation requires prolonged and careful trituration to produce a perfectly smooth ointment. Its efficacy is increased by the incorporation of lanoline, 1 part in 3 of vaseline, owing to the slow hydrolysis which the lanoline undergoes. This ointment is used largely in the treatment of conjunctivitis, especially the phlyctenular form; and in the treatment of blepharitis, and for helping to clear corneal scars. It acts as a mild irritant and antiseptic.

**Zinc Oxide and Icthyol Ointment.**

Icthyol	gr. ij
Zinc oxide	gr. v
Lanoline	℥j
Vaseline flav.	ad ℥ij

Used in the treatment of angular conjunctivitis and occasionally in blepharitis.

(4) **Ophthalmic Lamels or Tablets.**—These consist of minute gelatine discs or compressed tablets in which any of the drugs already mentioned may be incorporated. They are made up by wholesale chemists under various proprietary names, and are applied to the conjunctiva of the everted lower lid by means of a small camel-hair brush. The disc should be allowed to dissolve in the lacrymal fluid before the lid goes back into position, otherwise the sensitive cornea comes into contact with the concentrated drug, causing a good deal of pain. Lamels are very convenient on account of their portability, their keeping qualities, and the accuracy with which the required dose of the drug can be administered.



# APPENDIX

## REQUIREMENTS OF CANDIDATES FOR ADMISSION INTO THE PUBLIC SERVICES

### COMMISSIONS IN THE ARMY

The minimum standards of acuteness of vision with which a candidate for a commission will be considered fit are as follows :—

<i>Standard I</i>	
<i>Right Eye</i>	<i>Left Eye</i>
Distant vision.—V = 6/6.	V = 6/6.
Near vision.—Reads 0, 6.	Reads 0, 6.
<i>Standard II</i>	
<i>Better Eye</i>	<i>Worse Eye</i>
Distant vision.—V = 6/6.	V, without glasses = not below 6/60; and after correction with glasses = not below 6/24.
Near vision.—Reads 0, 6.	Reads 1.
<i>Standard III</i>	
<i>Better Eye</i>	<i>Worse Eye</i>
Distant vision.—V, without glasses = not below 6/60, and after correction with glasses = not below 6/6.	V, without glasses = not below 6/60; and after correction with glasses = not below 6/12.
Near vision.—Reads 0, 8.	Reads 1.

Each eye must have a full field of vision as tested by hand movements.

Squint or any morbid condition of the eyes or of the lids of either eye liable to aggravation or recurrence will cause the rejection of the candidate.

Each eye will be examined separately, and the lids must be kept wide open during the test. The candidate will be required to read the tests in ordinary daylight.

Inability to distinguish the principal colours will not be regarded as a cause for rejection, but the fact will be noted in the proceedings, and the candidate will be informed.

The degree of acuteness of vision of all candidates for commissions will be entered in the proceedings as follows :—

V.R. = ..... : with glasses = ..... Reads.....  
V.L. = ..... ; with glasses = ..... Reads.....

No relaxation of the standard of vision will be allowed.

### COMMISSIONS IN THE ROYAL NAVY

Blindness or defective vision, squint, imperfect perception of colours, fistula lachrymalis, or any chronic disease of the eyes or eyelids renders the candidate unfit. Candidates for first appointments in the Royal Marines (R.M.A. and R.M.L.I.) must possess full normal vision as determined by Snellen's tests, each eye being separately examined. Candidates for Naval Cadetships at the Royal Naval College, Dartmouth, must possess full normal vision, viz., 6/6, and be able



to read  $D = 0/6$  as determined by Snellen's test types, each eye being separately examined. A high degree of hypermetropia will disqualify. Candidates for Naval Cadetships (Special Entry) : The standard of distant vision on entry is—one eye  $6/6$ , and the other not less than  $6/12$  without glasses. The defect must be due to refractive errors. For near vision they must be able to read  $D = 0.6$  without glasses with each eye. A high degree of hypermetropia will disqualify. This lower standard will only be accepted on the clear understanding that these officers will undergo a further test of eyesight on the completion of their Sub-Lieutenant's examination at the schools, and a further examination if considered necessary on attaining the age of twenty-five.

#### RECRUITS FOR THE ROYAL NAVY AND ROYAL MARINES

1. For candidates for the Seaman Class (including Boys and Youths), Royal Marines (excluding Marine Bandsmen), Engine Room Artificers, Ordnance Artificers, Boy Artificers and Ship's Cooks, full normal vision is required, viz.,  $6/6$  each eye tested separately.

2. For candidates for Electrical Artificers, other Artisan Ratings (Shipwrights, Joiners, Blacksmiths, Plumbers, Painters, &c.), and Stokers, the vision must be  $6/9$  each eye tested separately.

3. For Sick Berth Staff and Royal Marine Band Boys,  $6/12$  each eye tested separately.

4. For all other ratings, including Writers, Victualling, Assistant Boy Writers, Victualling Boys, Officers' Stewards and Cooks, and Boy Servants, the vision must not be less than  $6/12$  both eyes.

5. For all ratings, except Writers, Officers' Stewards and Cooks, or Royal Marine Bands, the colour sense must be normal.

6. Marine Bandsmen, Sick Berth Staff, Writers, Victualling ratings, and Officers' Stewards and Cooks are allowed to wear glasses, but defects of vision must only be due to errors of refraction, and must be capable of correction to  $6/6$  Snellen by means of glasses, and the candidate must be able to read  $D = 0.6$  without the aid of glasses.

7. To determine the acuity of vision, Snellen's letter types are used, and the colour sense is determined by means of the Edridge Green Colour Perception Lantern ; if not available, by means of the bead test.



## GLOSSARY

- Amaurosis** is a serious defect of vision without any visible disease of the eye.
- Amblyopia** is a defect of vision without any visible disease of the eye.
- Ametropia** is a defect in the refractive system of the eye, *e.g.*, hypermetropia, myopia, astigmatism.
- Anisometropia** is inequality in the refraction of the two eyes.
- Aphakia**, absence of the lens.
- Argyrosis** is a discoloration of the conjunctiva, the result of prolonged use of silver preparations.
- Asthenopia**, eye-strain.
- Astigmatism** is that condition in which a point source of light cannot be brought to a focus upon the retina without the aid of a cylindrical lens.
- Black cataract.** An exaggerated form of senile lens sclerosis with pigment formation. The pigment formation is associated with the production of tyrosin, a degeneration product of lens proteins.
- Blepharitis**, inflammation of the edge of the eyelid.
- Buphthalmos**, general enlargement of the eyeball, due to infantile glaucoma.
- Chalazion**, a granuloma of a Meibomian gland, the result of obstruction to the duct.
- Chemosis**, a condition of marked œdema of the ocular conjunctiva, which projects forward and overlaps the corneal margin.
- Coloboma**, a gap (*e.g.*, in iris or choroid.)
- Cornea, band-shaped opacity** (transverse calcareous film), a degenerative change, usually in a diseased eye, in which a dense band of opacity is formed across the cornea.
- Cyclitis** is inflammation of the ciliary body.
- Cycloplegia**, paralysis of the ciliary muscle.
- Dacryoadenitis**, inflammation of the lacrimal gland.
- Dacryocystitis**, inflammation of the lacrimal sac.
- Diplopia**, double vision.
- Discission**, the operation of needling the lens.
- Ectasia**, a localised bulging of the wall of the eyeball.
- Ectropion**, eversion of the eyelid.
- Emmetropia**, the condition in which a point source of light at infinity is brought to a focus on the retina.
- Enophthalmos** is recession of the eyeball. Among other rare causes, it may arise in elderly people from loss of orbital fat.
- Entropion**, inversion of the eyelid.
- Epicanthus**, a vertical fold of skin at the inner canthus.
- Epiphora**, overflow of tears.



- Esophoria**, latent convergence.
- Exophoria**, latent divergence.
- Exophthalmos**, or proptosis, is prominence of the eyeball.
- Hemianopia** (syn. hemianopsia), loss of half the visual field in both eyes.
- Heterophoria**, latent squint.
- Hippus**, rhythmical changes in the size of the pupil.
- Hordeolum**, sty.
- Hypermetropia**, long sight.
- Hyperphoria**, latent upward squint of one eye.
- Hyp hæma**, blood in the anterior chamber.
- Hypopyon**, pus in the anterior chamber.
- Iridectomy**, excision of a piece of iris.
- Iridocyclitis**, inflammation of the iris and ciliary body.
- Iridodialysis**, detachment of the iris at its root.
- Iridodonesis**, tremulousness of the iris.
- Iris bombé**, ballooning of the iris.
- Iritis**, inflammation of the iris.
- Keratactasia**, ectasia of the cornea.
- Keratic precipitates** ("K.P.," syn. keratitis punctata), deposits on the back of the cornea in cyclitis.
- Keratitis, sclerosing**, inflammation of the cornea by extension from scleritis, usually tuberculous. It leads to a porcelain-white opacity of the cornea.
- Keratoconus**, conical cornea.
- Keratomalacia**, a nutritional disease of the cornea in which ulceration and necrosis take place, in children.
- Lagophthalmos**, inability to close the eyes, usually owing to scarring.
- Limbus**, the junction of conjunctival with corneal epithelium.
- Macropsia**, the state in which objects appear to be larger than normal.
- Metamorphopsia**, the state in which objects appear to be distorted.
- Microphthalmos**, congenital diminution in the size of the eye.
- Mucocele**, the distension with mucus or mucopus of a cavity lined by mucous membrane, *e.g.*, lacrymal sac, frontal, ethmoidal sinuses.
- Myosis**, contraction of the pupil.
- Mydriasis**, dilatation of the pupil.
- Mydriatic**, a drug which dilates the pupil.
- Myopia**, shortsight.
- Nystagmus**, short oscillatory movements of the eye.
- Ophthalmia**, a generic term applied to inflammation of the eye.
- Ophthalmoplegia**, paralysis of extrinsic or intrinsic muscles of the eye.
- Pannus**, the formation of a vascular or a fibro-vascular layer in the superficial strata of the cornea.
- Panophthalmitis**, acute suppuration of the eyeball.
- Papilla**, optic disc.
- Papilloedema**, edema of the optic disc.
- Paracentesis**, operation of tapping the eyeball.
- Phlyctenule**, a nodule of chronic inflammatory cells beneath the conjunctival or corneal epithelium.
- Photophobia**, fear of light.



**Pinguecula**, a yellowish mass formed in the conjunctiva in the palpebral fissure.

**Polyopia**, is present when more than two images of an object are produced, as in early cataract, and may be monocular or binocular.

**Presbyopia**, a state of insufficiency of accommodation due to age.

**Proptosis** (see Exophthalmos).

**Pterygium**, a fold of conjunctiva extending over the edge of the cornea at its inner or outer part.

**Ptosis**, drooping of the upper lid.

**Retinoscopy**, a shadow test for the refraction of the eye, made by observing the movement of light and shadow within the pupil during reflection of light into the eye from a mirror.

**Scotoma**, an area of blindness in the field of vision.

**Staphyloma**, localised bulging of the cornea or sclera.

**Strabismus**, squint.

**Symblepharon**, adhesion of lid in part or *in toto* to the eyeball after burns, ulcers of conjunctiva, or shrinkage of conjunctiva from trachoma or pemphigus.

**Synchisis**, liquefaction of the vitreous.

**Synechia**, adhesion of the iris to cornea or lens.

**Tarsorrhaphy**, operation of uniting the edges of the eyelids.

**Tenonitis**, inflammation of Tenon's capsule.

**Trachoma**, a form of conjunctivitis.

**Trichiasis**, ingrowing eyelashes.

**Uvea**, the vascular coat of the eyeball, consisting of iris, ciliary body and choroid.

**Uveitis**, inflammation of the uvea.

**Xerosis** is a degenerative change of conjunctiva or cornea in which the surface becomes whitish, dry and somewhat skin-like.



# INDEX

(The numbers in heavy type indicate the principal references to the subjects.)

- Accommodation, 41**  
 mechanism of, 149  
 in myopia, 48  
 range of, 49  
 relaxation of, 31
- Advancement operation, 258**
- Albinism, 154**
- Alum, 294**
- Amaurotic family idiocy, 197**
- Amblyopia, toxic, 200**  
 chemical, 201  
 diabetic, 200  
 from disuse, 232  
 in pregnancy, 200  
 scotoma in, 19  
 tobacco, 201  
 uræmic, 200
- Angeioma, 82**
- Aniridia, 154**
- Anthrax, 75**
- Arcus senilis, 143**
- Argyrol, 297**
- Arterial circle, greater, 150**  
 lesser, 150
- Arterio-sclerosis, 194**
- Astigmatism, 51**  
 irregular, 52  
 regular, 51, 52  
 symptoms of, 52
- Atropine, 295, 299**  
 in refractive work, 54  
 in wounds of cornea, 102
- Axis, optical, 40**
- Blepharitis, 76**  
 in astigmatism and hypermetropia, 54  
 in trachoma, 117
- Blind spot, 18**  
 change in glaucoma, 210
- Blindness, temporary, in distension of the  
 ventricle, 204**
- Boric acid, 292, 299**
- Bowman's membrane, 127**
- Buller's shield, 114**
- Buphthalmos, 4, 216**  
 in glaucoma, 211
- Canthotomy, 250**
- Canthus, 69**
- Carbolic acid, 293**  
 in treatment of corneal ulcer, 135
- Caruncle, 7, 69**
- Cataract, 170**  
 after-, 271  
 anterior polar, 111, 172  
 complicated (or secondary), 173  
 congenital, 172  
 cortical, 171  
 in diabetes, 173  
 extraction, 262  
 in glaucoma, 173  
 hard, 171  
 industrial, 172  
 in iridocyclitis, 173  
 intumescent, causing glaucoma, 217  
 lamellar, 172, 173  
 mature, 171  
 needling of, 103, 270  
 nuclear, 172  
 posterior polar, 172, 196  
 progressive, 172  
 senile, 172, 175  
 soft, 171  
 stationary, 171  
 in toxic conditions, 173  
 traumatic, 99, 103
- Cautery, puncture, 277**  
 in treatment of corneal ulcer, 134  
 trachoma, 120
- Cavernous sinus, thrombosis of, 237**
- Central artery, embolism of, 194**  
 spasm of, 195  
 thrombosis of, 195  
 vein, thrombosis of, 195
- Cerebro-macular disease, 197**
- Chalazion, 78**  
 spoon, 79
- Chamber, anterior, 10, 148**  
 exudate in, 158  
 haze in, 159  
 posterior, 148
- Choroid, anatomy of, 149**  
 coloboma of, 154  
 rupture of, 96
- Choroiditis, 165**  
 disseminated, 165  
 macular, 167  
 senile, 165  
 syphilitic, 165  
 Tay's, 166



- Choroiditis**—*continued*.  
 tuberculous, 165  
 in tuberculous meningitis, 165
- Ciliary body**, anatomy of, 149  
 injuries of, 100  
 ganglion, 152  
 injection, 157  
 vessels, 150  
 anterior, 145  
 posterior, 146
- Cocaine**, 293
- Colour**, blindness, tests for, 17  
 sense, 17
- Conical cornea**, 143, 276
- Conjunctiva**, anatomy of, 105  
 burns of, 91  
 carcinoma of, 122  
 congenital abnormalities of, 106  
 cysts of, 122  
 degeneration of, 121  
 dermoid of, 122  
 functions of, 105  
 granuloma of, 81, 118  
 hæmorrhage of, 91  
 inclusion bodies, 118, 119  
 inflammation of, 107, 123  
 inspection of, 7  
 neoplasm of, 122  
 papillæ on, 118  
 phlyctenule of, 123, 124  
 sarcoma of, 122  
 scarring of, in trachoma, 118  
 wounds of, 91  
 xerosis of, 122
- Conjunctivitis**, 54, 107  
 angular, 107, 112  
 catarrhal, simple, 107, 112  
 chronic, 108, 113, 132  
 follicular, 115, 119  
 gonococcal, 110  
 interstitial, 115  
 membranous, 111  
 mucopurulent, 108  
 ophthalmia neonatorum, 109  
 phlyctenular, 123  
 purulent, 109, 110, 113  
 spring catarrh, 119, 120  
 trachoma, 113, 115, 116, 119, 121  
 tuberculous, 115  
 vernal catarrh, 119, 120
- Convergence**, 64
- Copper**, citrate, 299  
 sulphate, 297
- Cornea**, abrasion of, 92  
 anæsthesia of, in glaucoma, 208  
 anatomy of, 127  
 burns of, 91  
 conical, 143, 276  
 deep striation of, 157  
 dermoid of, 106  
 ectasia of, 188  
 examination of, 8, 21  
 foreign body in, 20, 92
- Cornea**—*continued*.  
 haze of, 157  
 infiltration of, 129  
 inflammation of, 123, 129  
 œdema of, 129  
 opacity of, 24, 30, 131  
 pannus, 113, 116, 118, 119  
 paracentesis of, 276  
 perforating wounds of, 98, 101, 102, 277  
 perforation of ulcer of, 126, 136  
 sensitivity of, 9  
 serpiginous ulcer of, 87, 132, 135  
 tattooing, 276  
 ulcer of, 101, 111, 124  
 ulceration of, 118, 119, 126, 132, 134  
 vascularisation of, 130
- Corneal magnifier**, 20
- Cyclitis**, 158  
 "K.P." in, 11
- Cyclodialysis**, 94
- Cyclophoria**, 63
- Cyst**, dermoid, 82  
 of gland of Moll, 82  
 implantation, 122  
 lymphatic, 122
- Cytoid bodies**, 193
- Dacryo-adenitis**, 83
- Dacryocystitis**, 87, 88
- Dacryocystorhinostomy**, 246
- Dendritic ulcer**, 138
- Descemet's membrane**, 127
- Dionine**, 297
- Disc**, atrophy of, in glaucoma, 209  
 waxy in retinitis pigmentosa, 196  
*Also vide* Optic Atrophy and Optic Disc.
- Disseminated sclerosis**, optic atrophy in, 204  
 optic neuritis in, 204  
 scotoma in, 19
- Duboisine**, 295
- Ectropion**, 75, 80  
 operation for, 246
- Enophthalmos**, 4
- Entropion**, 79  
 in trachoma, 117  
 operation for, 248
- Epicanthus**, 79, 232
- Epiphora**, 72, 83, 87
- Episcleritis**, 146
- Epithelioma**, 82
- Erysipelas**, 75
- Eserine**, 102, 296, 299
- Esophoria**, 63
- Eversion of lid**, 5
- Exophoria**, 63
- Exophthalmos**, 4
- Eye**, deviation of, primary, 225  
 secondary, 224  
 examination of, by direct ophthalmoscopy, 28



**Eye—continued.**

- examination of, by distant direct ophthalmoscopy, 23
- by indirect ophthalmoscopy, 25
- by oblique focal illumination, 20
- transillumination, 34
- optical structure of, 39
- Eyeball**, atrophy of, 156
- concussion injuries of, 91, 98
- congenital abnormalities of, 236
- enucleation of, 259
- examination of, 5
- excision of, 103
- foreign body within, 103
- inflammation of, 101
- movements of, 4
- rupture of, 100
- Eyelid**, abnormalities of, 73
  - abscess of, 75
  - anatomy of, 69
  - carcinoma of, 82
  - cellulitis of, 75
  - congenital coloboma of, 73
  - cysts of, 82
  - ecchymosis of, 74
  - emphysema of, 74
  - examination of, 5
  - inflammation of, 75
  - injuries of, 74, 76
  - neoplasms of, 81
  - œdema of, 74
  - papilloma of, 82
  - plexiform neuroma of, 82
  - rodent ulcer of, 83
  - syphilis of, 76
  - tuberculosis of, 76
- “Finger-counting,” 13
- Fixation point**, 18
- Fluorescein**, 298
  - use of, in injuries of cornea, 9, 92, 99
- Forceps**, fixation, 255
  - iris, 268
  - Tyrrrell's, 119
- Fornix conjunctivæ**, 106
- Frost Lang operation**, 262
- Fundus**, examination of, 27, 33
  - changes in myopia, 50
- Glaucoma**, 208
  - congestive, 213
  - early signs in chronic, 18
  - field loss in, 17, 210
  - non-congestive, 215
  - primary, 212
  - secondary, 161, 216
  - treatment, 215
- Gonococcus**, 109, 112
- Gonorrhœa**, treatment, 206
- Granuloma**, polypoid, 81
- Hemianopsia**, bitemporal, 17, 282
  - (vel Hemianopia) homonymous, 17, 282
- Herpes febrilis corneæ**, 138

- Hess's operation**, 251
- Heterochromia iridis**, 153
- Heterophoria**, 62
  - correction of, 64
  - test for, 63, 64
- Hirschberg's test**, 231
- Homatropine**, 296, 299
  - and cocaine, 54, 296
- Hordeolum** (or styte), 77
- Hotz-Anagnostakis' operation**, 249
- Hyoscine**, 296
- Hypermetropia**, 43
  - course of, 44
  - symptoms of, 45
  - varieties of, 44
- Hyperphoria**, 62
- Hyphæma**, 93, 94
- Hypopyon**, 87, 101, 132

**Illumination**, oblique focal, 20**Infant**, examination of cornea of, 9**Inspection**, 4**Iridectomy**, 272

- with cataract extraction, 268
- optical, 273

**Iridodialysis**, 94**Iridodonesis**, 11**Iris**, anatomy of, 148

- bombé, 158,
  - causing glaucoma, 217
- coloboma of, 154
- examination of, 11, 22
- function of, 151
- injuries of, 93
- nerve supply of, 151
- prolapse of, 99, 102, 111, 136, 275.
- tremulous, 170

**Iritis**, 84, 156, 157, 158

- causes of, 157
- complications of, 160
- diagnosis between glaucoma and, 161
- gonorrhœal, 156
- nodule on iris in, 158
- in scleritis, 146

**Keratic precipitates** (“K.P.”), 11, 22, 123, 158**Keratitis**, disciform, 139, 143

- fascicular, 124
- interstitial, 84, 139, 140
- neuroparalytic, 138
- neuropathic, 138
- phlyctenular, 84, 123
- sclerosing, 146
- signs and symptoms of, 131
- tuberculous, 139

**Keratocoele**, 135

- perforation following, 136

**Keratome**, 273**Koch-Weeks bacillus**, 108, 112, 118**Kuhnt-Szymanowski's operation**, 246



- Lacrimal apparatus**, anatomy of, 70  
 examination of, 7  
 canaliculus, anatomy of, 71  
   obstruction of, 84  
 cannula, 88  
 duct, obstruction of, 84  
 gland, 7, 83,  
   anatomy of, 70, 72  
   inflammation of, 83  
   neoplasm of, 83  
 papilla, 7, 70  
 probe, 85, 88  
 punctum, 7  
   anatomy of, 71  
   dilatation of, 89  
 sac, 7  
   abscess of, 87, 88  
   anatomy of, 71  
   excision of, 243  
   syrringing of, 87, 89  
 syringe, 88
- Lacrymation**, 83
- Lagophthalmos**, 76
- Lamina cribrosa**, anatomy of, 145  
 in glaucoma, 209  
 relation to optic nerve, 199
- Lang's knife**, 274
- Leber's atrophy**, 205
- Lens**, in accommodation, 171  
 anatomy of, 170  
 congenital abnormality of, 172  
 dislocation of, 95  
 examination of, 11, 22  
 inflammatory affections of, 173  
 injury of, 95, 99  
 in old age, 171  
 opacity in, 30, 95  
 subluxation of, 24, 173
- Lenses**, 35  
 cylindrical, 35  
 decentration of, 38  
 prismatic, 36  
 spherical, 35
- Leucoma**, 9, 138  
 adherens, 137
- Light sense**, 14
- Line**, fixation, 40  
 visual, 40
- Liquor hamamelidis**, 113, 292
- Macula**, 9, 138
- Macular atrophy**, senile, 196  
 fan, 303
- Magnet**, extraction, 104, 277  
 Haab's, 104  
 Mellinger's, 104, 277
- Media**, opacity in, 2
- Meibomian cyst**,  
 gland, 5, 69, 70  
 abscess of, 78
- Meningitis**, following suppuration in orbit  
 and eyeball, 156
- Mercurial ointments**, 300
- Mercury perchloride**, 293, 298
- Microphthalmos**, 74
- Molluscum contagiosum**, 81
- Mooren's ulcer**, 138
- Morax-Axenfeld bacillus**, 108, 112
- Motais' operation**, 253
- Mucocele**, 87, 88
- Mule's operation**, 260
- Muscles**, action of, 218  
 extrinsic, 218  
 paralysis of, 221  
   causes of, 225  
   site of lesion in, 226
- Mydriatics**, 152
- Myopia**, 4, 46, 167  
 accommodation in, 48  
 ætiology of, 47  
 course of, 46  
 signs of, 49  
 symptoms of, 48
- Myotics**, 152
- Nævus**, pigmented, 106, 122  
 vascular, 106
- Nasal sinus**, inflammation of, 240
- Naso-lacrimal duct**, anatomy of, 71  
 obstruction of, 84
- Nebula**, 9, 138
- Needling**, 270
- Nettleship's dilator**, 89
- Nystagmus**, 279  
 in albinism, 155
- Opacity in cornea**, 24, 30  
 in lens, 30, 95  
 in media, 24, 30  
 in vitreous, 24, 31, 50, 95
- Operation**, canthotomy, 250  
 cataract, 262  
 cautery, puncture, 277  
 cornea, 276  
 dacryocystorhinostomy (West), 246  
 discussion, 270  
 ectropion, 246  
 entropion, 248  
 enucleation, 259  
 excision of lacrimal sac, 243  
 Frost Lang, 262  
 general considerations, 242  
 Hess', 251  
 iridectomy, 272  
   with cataract extraction, 268  
   optical, 144, 273
- Motais', 253**
- Mule's, 260**
- muscle tarsal (Hotz-Anagnostakis), 249**
- needling, 270**
- paracentesis, 276**
- ptosis, 251**



**Operation—continued.**

- recession, 256
- sclero-corneal trephine, 273
- skin-grafting, 248
- skin-tarsal (Kuhnt-Szymanowski), 246
- squint, 254
- tarsorrhaphy, 251
- tattooing, 276
- tenectomy, 257
- tenotomy, 255
- three-snip, 243
- trichiasis, 248
- Ophthalmia neonatorum**, 109
- Ophthalmoscope**, 65
  - Marple's, 1
  - Morton's, 1, 28
  - refractive error by, 32
- Ophthalmoscopy**, direct, 28, 65
  - distant direct, 23
  - indirect, 25, 67
    - compared with direct, 33
- Optic disc**, coloboma of, 154
  - examination of, 26, 32
- Optic nerve**, 188, 199
  - anatomy of, 199
  - atrophy of, 17, 97, 205
    - in atoxyl poisoning, 201
    - causes of, 206
    - in Leber's disease, 205
  - degenerative diseases of, 205
  - hæmorrhage of, 97
  - inflammatory affections of, 202
  - injuries of, 97
  - neuritis, 204
    - causes of, 204
  - new growths of, 206
  - traumatic affections of, 200
- Ora serrata**, 149
- Orbit**, anatomy of, 235
  - carcinoma of, 240
  - cellulitis of, 236
  - differential diagnosis of affections of, 238, 239
  - examination of, 5
  - inflammation of, 236
    - treatment of, 237
  - injuries of, 236
  - neoplasms of, 236, 240
  - osteoma of, 241
  - periostitis of, 236
  - surgical emphysema of, 236
- Palpation**, 4
- Pannus**, 116, 117, 118, 119
  - in old inflamed eyes, 144
- Panophthalmitis**, 101, 135
- Papillitis**, 97
- Papilloedema**, 97, 202
  - pseudo-, 203
- Parallax**, 22, 23
- Perimeter**, Holth, 16
  - Lister, 16

- Pilocarpine**, 297
- Pinguecula**, 121
- Plica semilunaris**, 7, 69
- Pneumococcus**, 112
- Presbyopia**, 41
  - premature, 42
    - in glaucoma, 208
- Priestley Smith's tape**, 236
- Projection**, 15
  - false, 224
- Proptosis**, in Graves' disease, 237
  - investigation of, 237
  - in optic nerve tumour, 207
    - due to orbital hæmorrhage, 236
- Protargol**, 298
- Pterygium**, 121, 278
- Ptosis**, congenital, 73
  - operation for, 251
- Pupil**, 11, 151
  - anomalies of, 153
    - Argyll-Robertson, 11
  - dilatation of, in glaucoma, 208
  - ectopia of, 154
  - in iritis, 157
  - occlusion of, 158
  - persistent pupillary membrane, 153
  - reactions, 11
  - reflexes, 152
  - seclusion of, 158
- Radium**, 83, 123
- Refraction**, 35
  - treatment of errors of, 54
- Retina**, 188
  - degeneration of, 195
  - detachment of, 96, 98, 100, 190
    - course of, 192
    - in iridocyclitis, 161
    - in renal retinitis, 193
    - signs and symptoms of, 191
  - diseases of, 189
  - glioma of, 191
  - new growths of, 197
  - traumatic affections of, 189
- Retinitis circinata**, 194
  - diabetic, 193
  - leucæmic, 194
  - pigmentosa, 195
  - proliferans, 194
  - renal, 193
- Retinoscopy**, difficulties in, 55
  - mirror, 1
  - theory of, 59
- Retro-bulbar neuritis**, 204
  - scotoma in, 19
- Sarcoma**, 83
- Sclera**, anatomy of, 145
  - inspection of, 8
  - wounds of, 100, 103



- Scleritis**, 146  
**Sclero-corneal trephining**, 273  
   trephine, 275  
**Scopolamine**, 296  
**Scotoma**, 18  
   caecocentral, 204  
   in choroidal atrophy, 166  
   in Leber's disease, 205  
   in retinitis pigmentosa, 196  
   in thrombosis of central vein, 195  
**Services**, visual test for, 301  
**Silver nitrate**, 298  
**Skin-grafting**, 248  
**Spectacles**, prescription of, 58  
**Speculum**, 255  
   tear duct, 244  
**Spring catarrh**, 120  
   compared with trachoma, 121  
**Squint**, 229  
   apparent, 232  
   concomitant, 229  
   divergent, treatment of, 234  
   gamma angle in, 231  
   operation for, 254  
**Staphyloma**, anterior, 111, 138, 147  
   equatorial, 147  
   in glaucoma, 211  
   posterior, 147  
   of sclera, 146  
**Strabismus**. *See* Squint.  
**Stye** (or hordeolum), 77  
   in astigmatism and hypermetropia, 54  
**Substantia propria**, 127  
**Suspensory ligament**, 149  
**Sutures**, Gaillard's, 248  
   Snellen's, 246  
**Symblepharon**, 91, 117  
**Sympathetic ophthalmia**, 101, 163  
**Synechiæ**, causing glaucoma, 217  
   in iritis, 158  
**Syphilis**, congenital choroido-retinitis, 196  
   treatment of, 290  
  
**Tarsorrhaphy**, 251  
**Tenon**, capsule of, 105, 235  
   inflammation of, 237  
**Tenotomy**, in squint, 255  
**Tension**, of eyeball, 12  
   in iritis, 160  
   in glaucoma, 208  
**Test-type**, Jaeger, 1  
   Snellen's, 1, 12  
**Therapeutics**, ocular, 290  
**Three-snip operation**, 243  
  
**Transillumination**, 34  
**Trichiasis**, 79  
   operation for, 248  
   in trachoma, 117  
**Tuberculin**, 290  
**Tuberculosis**, treatment of, 290  
**Tyrrrell's forceps**, 119  
  
**Undine**, 292  
**Uveal tract**, 148  
   acute suppurative inflammation of, 155  
   anatomy of, 148  
   blood supply of, 150  
   nerve supply of, 151  
   new growths of, 167  
   subacute uveitis, 156  
  
**Venæ vorticosæ**, 146, 150  
**Vertigo**, in false projection, 225  
**Vision**, acuity of, 12  
   distance, 12  
   field of, 14, 18  
   central scotoma of, 19, 201  
   changes of, 282  
   contraction of, in toxic amblyopia, 201  
   defect of, in glaucoma, 210  
   loss of, in coloboma of choroid, 154  
   peripheral, 14  
   near, 13  
**Vitreous**, 12, 183  
   anatomy of, 183  
   congenital anomalies of, 183  
   degenerative changes, 186  
   hæmorrhage into, 95, 100, 184, 186  
   inflammatory affections of, 184  
   opacity in, 31, 50, 95, 160, 186  
   prolapse of, 100  
   traumatic affections, 184  
  
**Xanthelasma**, 82  
**Xerosis**, 122  
**X-ray**, 83  
   photographs, 104  
  
**Zinc**, oxide, 300  
   sulphate, 113, 293, 298  
  
*Diplopia in Fig. 145, p. 224, is due to paralysis of the left superior rectus muscle.*



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